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RESULTS OF THE MINIMUM INSTRUMENTATION PROGRAM FOR THE CLARK CANYON DAM

DRAWING 699-600-114 & FIG. 1 MISSING

EAST BENCH UNIT - THREE FORKS DIVISION

PICK-SLOAN MISSOURI BASIN PROGRAM

MONTANA

BY

FRANK CALCAGNO, JR.

SEPTEMBER 1985

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMTION
UPPER MISSOURI REGION

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CLARK CANYON DAM

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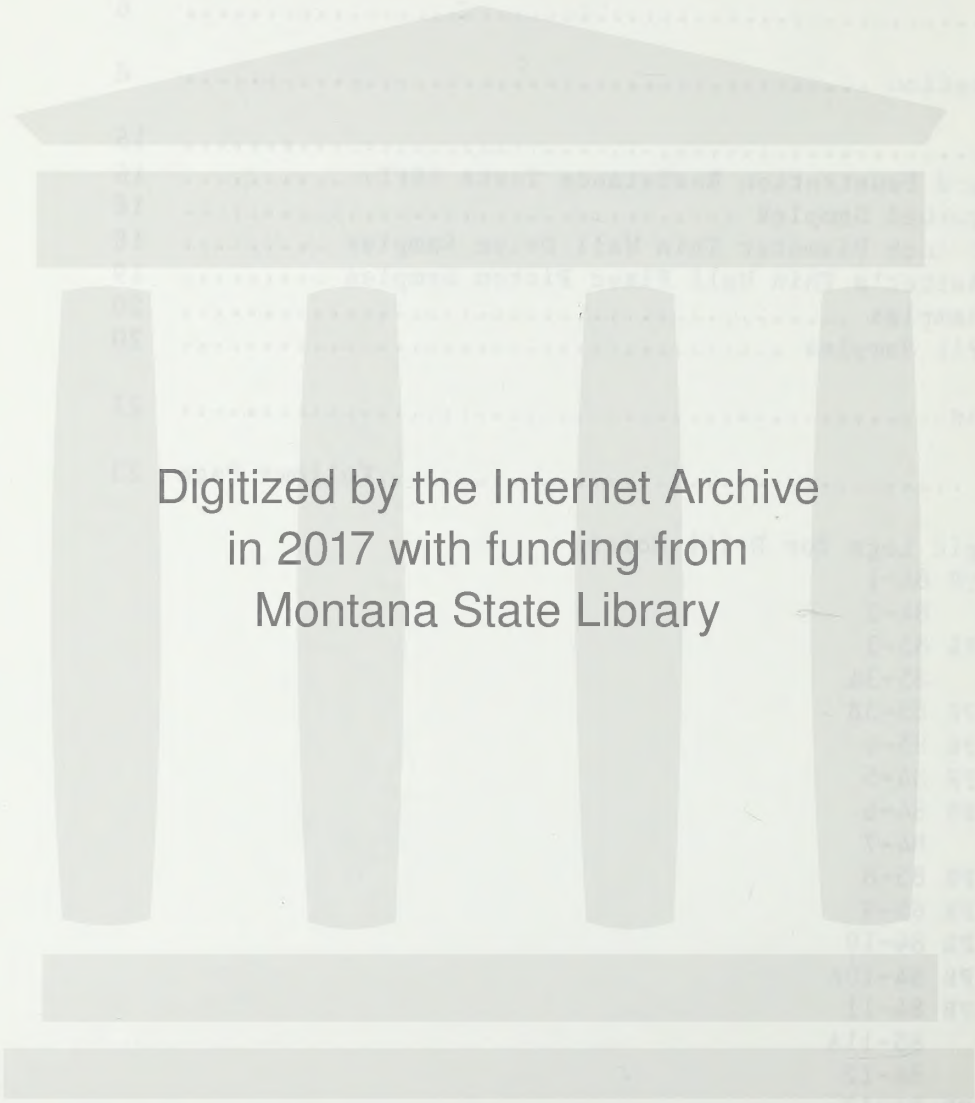

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Table 1 - Clark Canyon Dam - Right Abutment Observation Wells in Seep

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Figure 1 - Right Abutment Seepage - 1984

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INTRODUCTION

Instrumentation at Clark Canyon Dam at the time of the June 1980 SEED examination consisted of 13 observation wells, 21 embankment measurement points, 104 structural measurement points, and a V-notch weir and a Parshall flume to measure seepage and toe drain flows. Measuring of the water levels in the 13 observation wells and recording the discharge rates of the toe drains were discontinued in 1972. The monitoring program was reestablished in the summer of 1984. Periodic surveys of the embankment and structural measuring points have not indicated any abnormal conditions.

The seepage conditions at the time of the SEED evaluation could not be adequately assessed. Consequently, a minimum instrumentation program was developed and was later modified. These instructions were documented in the following memorandums to the Regional Director:

1. Assistant Commissioner's (Engineering and Research) memorandum dated October 7, 1982, subject, "Minimum Instrumentation Program Clark Canyon Dam - East Bench Unit - Three Forks Division - Pick-Sloan Missouri Basin Program, Montana".

2. Assistant Commissioner's (Engineering and Research) memorandum dated June 13, 1984, subject, "Modifications to the Field Exploration Program - Clark Canyon Dam, East Bench Unit - Three Forks Division - Pick-Sloan Missouri Basin Program, Montana".

3. Assistant Commissioner's (Engineering and Research) memorandum dated September 27, 1984, subject, "Additional Instrumentation and Field

Explorations - Clark Canyon Dam - East Bench Unit - Three Forks Division -Pick-Sloan Missouri Basin Program, Montana".

4. Assistant Commissioner's (Engineering and Research) memorandum dated March 1, 1985, subject, "Modifications to the Field Exploration Program - Clark Canyon Dam - East Bench Unit - Three Forks Division - Pick-Sloan Missouri Basin Program, Montana".

Additional changes were made to the program as data was gathered. These were not documented as they were through verbal communications between Regional and E&R Center personnel.

This report discusses in detail all of the work that was completed for the instrumentation program, and provides background information on the geology, construction and seepage that is related to Clark Canyon Dam. Additional information, such as gradations of toe drain (original), embankment and foundation materials, will also be presented in the Testing Section of this report. The downstream drain modification and construction completed during 1984 and 1985 will not be covered.

GEOLOGY

The dam is situated within the Beaverhead River Canyon with steep (1-1/2H:1V) slopes on the left (west) bank and flat (5H:1V) slopes on the right (east) bank.

The dam is founded on Holocene alluvial deposits in the stream section, and Holocene alluvial fan deposits over the Tertiary Beaverhead Formation

(conglomerates and lake sediments) in the right abutment. Part of what has been classified as the Beaverhead Formation in the right abutment may actually be late Tertiary terrace deposits. However, due to their similarities with the uncemented conglomerates in the Beaverhead Formation, they could not be separated by drilling data. Engineering properties of both units would be similar and therefore, they are considered as one unit (Beaverhead Formation) for this report. Madison limestone of Mississippian age underlies the Beaverhead Formation in the right abutment and the alluvium deposits in the stream section. Badly broken Madison Limestone also forms the left dam abutment.

Three geologic cross-sections (Figures 2, 3, and 4) normal to the dam embankment were constructed from information derived from the 1984-85 drilling program. These cross-sections were originally prepared by the E&R Center (code D-230), and have been modified to reflect the final drilling information. Section 1-1 is at Station 17+00, section 2-2 is at Station 19+00, and section 3-3 is at Station 24+50.

In general, the Tertiary Conglomerate - Mississippian Limestone contact beneath the right side of the dam is essentially flat-lying with only minor surface irregularities. East of the dam, the contact drops off rapidly into an older buried channel. The limestone is hard (scratched by knife with difficulty), locally oxidized, and locally badly broken with calcite healed or clay lined joints. No solutional cavities were found in any of the limestone during drilling.

The Upper Cretaceous and Tertiary Beaverhead Conglomerate (may include late Tertiary terrace deposits) is composed of subrounded to subangular

limestone gravel in a slightly calcitic sand and fines matrix. The formation where penetrated by drilling is uncemented but compact. On average, the conglomerate is composed of approximately 55 percent gravel, 35 percent sand and 10 percent nonplastic fines. The thickness of the Beaverhead is variable, ranging from approximately 0 to over 250-feet east of the dam. It grades in composition both vertically and horizontally and is generally lenticular in nature.

The Holocene alluvial fan deposits developed as slope wash coming from the mountain flanks east of the dam. This material is also lenticular and grades both vertically and horizontally. It contains a much higher percentage of silt and fine sand than the underlying conglomerate. Gravels are less common but sand and gravel zones are found interfingered with the main deposit. In general, the material is less compact than the underlying conglomerate but appears to be fairly firm beneath the dam. In the seepage area, however, penetration resistance tests indicate that this material is less dense and much softer. This is probably the result of artesian pressures acting on the material and actually floating particles in a "quick" condition. Penetration resistance tests in this material beneath the dam were above 20 blows per foot while downstream of the dam in the boggy area, (DH 84-1 and 85-3) they were considerably below 20 blows per foot. This material is up to 30-feet-thick in places.

Holocene river alluvium deposits occur below the flood plain in the river channel. The deposits range from compact silty to clayey sand with gravel to clean sand and gravel. They are lenticular and contain discontinuous

channels that would be difficult, if not impossible, to locate by drilling. All penetration resistance tests conducted in this material exceeded 20 blows per foot.

A low angle thrust fault was encountered in the Madison Limestone in the cutoff trench from Station 17+50 to Station 22+00 during construction. Some faulting in limestone was logged in several bore holes drilled in the late 1940's, but none was reported in alluvial deposits. A several mile long thrust fault, located northwest of the site, with the closest mapped approach to the dam of 1/4 mile (USGS Map I-433), places Madison Limestone (±250,000,000 YBP) on strata of the Beaverhead Conglomerate (±30,000,000 YBP). The younger conglomerate is strongly folded and overturned in front of the thrust. The thrust is covered by apparently undisplaced Tertiary basalt flows north of the dam.

A cutoff trench 30 to 100 feet wide and 5 to 50 feet deep, was excavated between Stations 14+00 and 32+00. No cutoff was provided from Station 11+00 to Station 14+00 (extreme right abutment). The cutoff trench was excavated to bedrock from Station 17+50 (elevation 5470) to Station 32+00. Due to severely fractured and decayed limestone from Station 17+50 to Station 22+00, the cutoff trench had to be widened and deepened. From Station 17+50 to Station 11+00 the cutoff trench was excavated in alluvial fan deposits and the Beaverhead Formation. The embankment upstream and downstream from the cutoff trench in the stream and right abutment sections was generally founded in Holocene alluvium and fan deposits. The left side of the dam rests entirely on the Madison Limestone.

The foundation below the cutoff trench was grouted with 241 holes from Station 18+00 to Station 31+90. These holes accepted 49,903 sacks of cement in 22,945 linear feet of hole for an average grout "take" of 2.0 ft^3/ft of hole. No grouting was completed between Stations 11+00 and 18+00.

SEEPAGE

Seepage has never occurred along the spillway, groins of the dam or the dam embankment. Water seeps, however, have existed downstream from both the right and left abutments for a number of years, with one below the right abutment being observed during the 1980 SEED examination.

The seeps on the left abutment side occur only during high reservoir conditions. Broken and weathered zones within the limestone slowly seep water into a collector ditch near the downstream camping area. Flows are monitored by a V-notch weir placed above the junction of the collector ditch and the spillway channel.

The area of concern on the right abutment extended from the downstream toe of the dam for a distance of about 200 feet. In plan view, the boggy area was roughly triangular in shape and was 200 feet wide by 600 feet long, following the 8- and 12-inch toe drains from about dam Station 16+50 to Station 22+50. Seepage did not occur in the embankment above the toe drains. The ground surface within the boggy area was saturated, spongy, and supported a thick growth of grass. At several locations, springs (less than 1 gal/min) were observed "boiling" gently upward apparently under

hydrostatic pressure. Springs ran clear and were surrounded by very soft silts. The estimated total flow from the seepage area was 5 gal/min. in June of 1980.

During the early summer of 1984, the reservoir behind Clark Canyon Dam reached record levels (Elevation 5564.7 on June 25), and water was released through the spillway for the first time. The seepage area in the right abutment became more visible and sand boils increased in size and number. The extent of the seepage area as it existed during the early summer of 1984 is shown on Figure 1.

A sand and gravel berm was placed adjacent to the dam along the upstream portion of the seep to stabilize the area and to prevent piping of the foundation. An attempt was made to strip the topsoil prior to constructing the berm. As the topsoil was being removed, a small, dozer induced mud flow occurred, originating from the saturated surficial portion of the right abutment. The mud flow occurred on June 29, 1984, and moved downstream along the dam toe. The flow destroyed a recently installed observation well (DH 84-1). The saturated silty sand and alluvial fan deposits would support the dozer for one pass and then act in a "quick" condition, burying the dozer on subsequent passes. The gravel blanket was very difficult to place because of these foundation problems. The location of this berm is shown on Figure 1.

From late July to early August, 15 temporary observation wells were installed around the boggy area to monitor the increased seepage at the toe of the dam. Locations of these wells (OW 84-201 through -215) are shown on

Figure 1 and Drawing 699-600-114. Well characteristics are described on Table 1. Six of these wells (OW 84-201, -202, -203, -206, -210, and -213) were later destroyed when a drainage system was installed. Figure 1 shows the approximate outer margin of the seep area between June 24 and July 1, 1984, and also the water table as it existed on August 20, 1984.

During late 1984 and early 1985, the right abutment toe drain was replaced and drains were installed in the seepage area to lower the ground water table. Seepage has not been a problem since this program was completed and the entire surface area of the boggy area has been stabilized and dried up. The area will be closely monitored to insure that the drainage system is performing in a satisfactory manner.

The left abutment toe drain is also being replaced at the present time. Both left and right toe drains were found to be damaged and in need of repair.

INSTRUMENTATION

Work on the instrumentation program was started in May of 1984 and intermittently continued through July of 1985. The program involved rehabilitating some of the existing wells and installing new ones in the embankment and foundation. Associated with this was the collecting and testing of drill core samples.

Five wells (DH 114, 122, 134, 140, and 141) were drilled during 1960 or 1965 to monitor the ground water in the area of Clark Canyon Dam. Galvanized, 1-1/4-inch-diameter metal pipe was installed in each well upon

completion. During late spring of 1984, 3/4-inch-diameter plastic pipe was inserted inside of the existing metal casings. This rehabilitation was done to insure that monitoring could be continued even if the old metal pipes corroded and/or collapsed. The plastic pipe in DH 140 was also extended several feet to prevent water from flowing from the well during high reservoir periods. Protective metal pipes with locking caps were placed around each of the rehabilitated wells.

Two wells DH 142 and W-4 were not modified and remain as they were when originally drilled.

Surveys conducted during August of 1985 established new elevations for all of the older wells. These elevations along with other pertinent data are listed on Table 2. Geologic logs for all of the older wells are not included in this report but are available in the Upper Missouri Regional Office.

Most of the instrumentation program developed for the SEED program was centered around the completion of the 17 new holes that were drilled during 1984 and 1985. These holes include PR 84-1, -5, -6, -10, -10A, -11, and -13 and DH 84-2, -7, and -12 drilled in 1984, and PR 85-3, -3B, and -9 and DH 85-3A, -4, -8, and -11A drilled in 1985. A total of 26 porous tube piezometers and 3 slotted pipes were installed in the 17 drill holes. Locations of these holes are shown on Drawing 699-600-114. Detailed descriptions of geologic materials and piezometer installations are on the geologic logs which are included in the appendix of this report. Table 2 also summarizes pertinent data for these wells.

Associated with the drilling and installation of the piezometers was the collection and testing of materials samples. This will be discussed in detail under the "Testing" section of this report.

A summary of the work completed at each of the well locations follows:

PR 84-1 is located approximately 200 feet downstream of dam Station 17+00. Total depth is 49.2 feet. The upper 18.0 feet contains Holocene alluvial fan deposits with Upper Cretaceous to Lower Tertiary Beaverhead Conglomerate from 18.0 to 30.9 feet and Madison Limestone below 30.9 feet. This hole was drilled in the seepage area in the right abutment and had standard penetration tests (SPT) exceeding 20 blows/foot except at the follwing intervals: 0 blows/foot from 0 to 10 foot depth, and average of 11 blows/foot from 10 to 21.0 foot depth. (Sandy silt was found at 0 to 9.0 feet and sand at 14.5-18.0 feet). Two porous tube piezometers were set in this hole (the upper in conglomerate and the lower in limestone). This drill hole was destroyed by the mud flow of June 29, 1984.

DH 84-2 is located approximately 8 feet upstream of the dam crest at Station 19+00. Total depth is 120.6 feet. Drilling penetrated Zone 2 material to a depth of 22 feet and Zone 1 embankment from 22.0 to 99.1 (?) feet. The Beaverhead Conglomerate is present from 99.1 to 105.6 feet with Madison Limestone below 105.6 feet. Three porous tube piezometers were set in the hole (the upper 2 in Zone 1 and the lower in limestone).

PR 85-3 is located approximately 200 feet downstream of dam Station 17+00. Total depth is 48.0 feet. The upper 9.5 feet consists of

fill (gravel blanket spread out during 1984). Alluvial fan deposits are present from 9.5 to 25.8 feet with the Beaverhead Conglomerate from 25.8 to 38.2 feet. Madison Limestone lies below 38.2 feet. The only SPT tests which did not exceed 20 blows/foot are at 3 feet (in fill, with 18 blows/foot) and at 18 to 22 feet (in silty sand, ranging from 17 to 5 blows/foot). Two porous tube piezometers were set in this hole (the upper in conglomerate and the lower in limestone). This drill hole replaced PR 84-1 which had been destroyed in the 1984 mud flow.

DH 85-3A is located adjacent to PR 85-3. Total depth is 27.0 feet. The upper 4.8 feet consists of fill (gravel blanket) with alluvial fan deposits below (from 4.8 to 23.5 feet). This hole bottomed in conglomerate (from 23.5 to 27.5 feet). The hole was drilled to collect undisturbed (Butter's) samples of silty sand zones. Sampling results are discussed in the "Testing" section of this report. Piezometers were not installed in this hole.

PR 85-3B is also located adjacent to PR 85-3. Total depth is 23.4 feet. The upper 4.3 feet consists of fill (gravel blanket) with alluvial fan deposits present below (from 4.3 to 23.4 feet). One SPT test was conducted at the bottom of this hole which showed a blow count of 25 blows/foot. This drill hole was also used to collect undisturbed samples of the sand and silty sand as these zones could not be sampled in DH 85-3A. Sampling results are discussed in the "Testing" section of this report. Piezometers were not installed in this hole.

PR 85-4 is located approximately 70 feet downstream of dam Station 19+00. Total depth is 86.1 feet. The upper 28.0 feet consists of

Zone 2 material with 11 feet of Zone 1 embankment below (28.0 to 39.0 feet). Zone 2 material was again encountered from 39.0 to 63.5 feet. Alluvial fan deposits lie below the dam from 63.5 to 77.9 feet with Madison Limestone below 77.9 feet. All SPT tests exceeded 20 blows/foot. Two porous tube piezometers were set in the hole (the upper in the Zone 2 filter and the lower in the Beaverhead Conglomerate).

PR-84-5 is located approximately 200 feet downstream of dam Station 19+00. Total depth is 32.3 feet. The upper 9.0 feet contains Zone 3 embankment. Zone 2 filter material is present from 9.0 to 18.0 feet. Holocene alluvial fan deposits are present from 18.0 to 24.6 feet with the Beaverhead Conglomerate below at 24.6 to 31.1 feet. Madison Limestone lies below 31.1 feet. All SPT tests exceeded 20 blows/foot. Two porous tube piezometers were set in this hole (the upper in Zone 2 and the lower in the Beaverhead Conglomerate).

PR 84-6 is located approximately 400 feet downstream of dam Station 19+00. Total depth is 30.6 feet. The upper 6.0 feet contains alluvial fan deposits. The Beaverhead Conglomerate lies between 6.0 and 13.0 feet and the Madison Limestone lies below 13.0 feet. One SPT test (at 5 feet) was at 20 blows/foot (below this depth SPT tests were well in excess of 20 blows/foot). Two porous tube piezometers were set in this hole (the upper piezometer in alluvial fan deposits and the lower in limestone).

DH 84-7 is located approximately 8 feet upstream of dam Station 24+50 on the dam crest. Total depth is 158.0 feet. The upper 116.0 feet

contained Zone 1 embankment (no Zone 2 material was identified at the top). Below the embankment lies 29.3 feet of river alluvium with Madison Limestone below a depth of 145.3 feet. Three porous tube piezometers were set in this hole (the upper piezometer is in Zone 1 embankment; the middle piezometer is in river alluvium; and the lower in the Madison Limestone).

PR 85-8 is located approximately 85 feet downstream of dam Station 17+00. Total depth is 81.5 feet. The upper 41.5 feet consists of embankment (Zone 2 material) with alluvial fan deposits below (from 41.5 to 61.5 feet). Beaverhead Conglomerate is present from 61.5 to 71.0 feet with Madison Limestone below 71.0 feet. All SPT tests exceeded 20 blows/foot. Two porous tube piezometers were set in this hole (the upper in Zone 2 material and the lower in Beaverhead Conglomerate).

PR 85-9 is located approximately 52 feet downstream of dam Station 24+50. Total depth is 131.6 feet. The upper 7.5 feet consists of Zone 2 material with Zone 1 embankment from 7.5 to 90.0 feet. Zone 2 material is again present form 90.0 to 100.0 feet. Below the dam lies 21.5 feet of river alluvium (100.0 to 121.5 feet). Madison Limestone lies below 121.5 feet. All SPT tests exceeded 20 blows/foot, with the exception of 18 blows/foot at 41 feet and 20 blows/foot at 53 feet. Two porous tube piezometers were set in the hole (the upper in the Zone 2 filter and the lower piezometer in river alluvium).

PR 84-10 is located approximately 330 feet downstream of dam Station 24+50. Total depth is 20.5 feet. The upper 16.0 feet consists of Zone 3 embankment with river alluvium present underneath to 20.5 feet. All SPT

tests were in excess of 20 blows/foot. A slotted 1-1/2-inch PVC pipe was installed in this hole upon completion. PR 84-10 had to be abandoned because of problems with drilling.

PR 84-10A lies adjacent to PR 84-10. Total depth is 54.0 feet. The upper 16.0 feet consists of Zone 3 embankment with 26.0 feet of river alluvium underlying the embankment material. Madison Limestone lies below 42.0 feet. All SPT tests exceeded 20 blows/foot. Two porous tube piezometers were set in this hole (the upper piezometer in river alluvium and the lower in limestone).

PR 84-11 is located approximately 500 feet downstream of dam Station 24+50. Total depth is 47.0 feet. The upper 36.0 feet consists of railroad fill and river alluvium with Madison Limestone below 36.0 feet. (Twisted metal shavings were found between 20.0 and 21.5 feet, therefore, Holocene river alluvium may lie between 21.5 to 36.0 feet in depth.) All SPT tests exceeded 20 blows/foot with the exception of a test at 6.0 feet (7 blows/foot) in silty sand. A slotted 1-1/2-inch PVC pipe was installed in this hole upon completion.

DH 85-11A lies adjacent to PR 84-11. Total depth is 10.4 feet. This hole is founded in railroad fill material and was drilled in order to collect undisturbed (Butter's) samples of soft silty sand. Refer to the "Testing" section for additional details.

DH 84-12 is located approximately 8 feet upstream of Station 17+00 on the dam crest. Total depth is 119.5 feet. The upper 9.0 feet consists of

Zone 2 filter material. Zone 1 embankment was encountered from 9.0 to 65.0 feet. Alluvial fan deposits were between depths of 100.5 and 106.7 feet. Madison Limestone lies below 106.7 feet. Four porous tube piezometers were set in this hole (the upper 1 on Zone 1 embankment, the next 2 piezometers in alluvial fan deposits, and the lowest piezometer in limestone).

PR 84-13 is located approximately 325 feet downstream of dam Station 16+50. Total depth is 13.4 feet. The upper 9.3 feet encountered alluvial fan deposits which were underlain by the Beaverhead Conglomerate. All SPT tests exceed 20 blows/foot. A slotted 3/4-inch PVC pipe was set in the hole upon completion. This hole was drilled at an arbitrary location in order to test the procedures for obtaining Butter's thin wall samples. This observation well was destroyed when the seepage area drainage system was installed in late 1984.

Drill hole numbers do not necessarily correspond to those assigned in the memorandums from the Engineering & Research Center. Hole numbers were adjusted to fit local conditions and to keep drill hole numbers in sequence (3 combined with 2, 8 combined with 7, 13 changed to 8, 3 replaced 1, and 13 is Butter's sample test hole). Drawing 699-600-114 was prepared and shows the location of each drill hole and the numbering system used for each site.

TESTING

A series of samples were collected at various locations in the dam embankment and foundation. Some of the samples were analyzed by commercial

laboratories in Billings, Montana, and by the Bureau's materials laboratory at Deerfield Dam. Other samples were collected and shipped to the E&R Center for testing. Tests (Standard Penetration Resistance) were also conducted in most drill holes. The sample collecting and testing program that was undertaken during the instrumentation program will be described by type as follows:

Standard Penetration Resistance Tests (SPT)

Standard penetration resistance tests were conducted in most of the drill holes. Originally these tests were to be performed at every 5 feet, but the test interval was later changed by verbal communications from the E&R Center to 2.5 foot centers.

All of the SPT testing had to be modified to fit field conditions. SPT tests were not conducted in the dam crest holes (DH 84-2, -7, and -12) as these were drilled with the E&R Center's Portadrill which did not have SPT capabilities. SPT tests were, however, completed in the embankment in holes drilled from the downstream dam face. In many instances, SPT tests could not be completed in the extremely gravely areas that were encountered in all of the dam's zones or in the Holocene (river alluvium and fan) or Tertiary (Beaverhead Conglomerate ?) deposits. The geologic logs of Drill Holes PR 84-1, -5, -6, -10, -10A, -11, and -13 and PR 85-3, -6, -8, and -9 show the depths where the penetration tests were taken and list the blow counts and moisture contents for each test.

Blow counts varied for different material and in many instances were affected by gravel in the test zone. In some areas, gravel could not be

cleaned from the hole and the test was abandoned. The following table lists the minimum, maximum, and average SPT blow count results for tests in all of the materials penetrated in the drilling program:

MATERIAL	NO. TESTS	MIN. BLOWS	MAX. BLOWS	AV. BLOWS
Zone 1 Embankment	16	18	100	47.8
Zone 2 Embankment	7	29	90	56.9
Zone 3 Embankment	3	45	250	113.7
Downstream Berm Fill	2	18	63	40.5
Railroad Fill	5	7	42	30.2
River Alluvium	11	28	167(?)	67.3
Alluvial Fan	17	0	167	34.1
Beaverhead Conglomerate(?)	8	12	250	60.4

All SPT tests were completed following the guidelines established in the ACER memorandum dated July 29, 1982, subject, "Supplement to the Earth Manual - Designation E-21, Penetration Resistance Testing and Sampling of Soil."

Undisturbed Samples

5-Inch Diameter Thin Wall Drive Samples

A total of 7 (seven) 5-inch-diameter thin wall drive samples were collected in the 3 holes (DH 84-2, -7, and -12) drilled from the crest of the dam. Four of the samples obtained were in Zone 1 embankment materials. Dry density of these samples ranged from 114.6 to 123.2 pounds per cubic foot and averaged 119.6 pounds per cubic foot. Moisture contents varied from 11.3 to 17.2 percent. Two samples were collected in alluvium deposits beneath the dam embankment in DH 84-7. In-place dry densities of these samples were 123.6 and 123.1 pounds per cubic foot with moisture contents of 14.9 and 13.2 percent, respectively. One sample was obtained in alluvial fan deposits beneath the dam embankment in DH 84-12. This sample had an in-place dry density of 107.2 pounds per cubic foot and a moisture content of 21.2 percent. Sample depths and additional data are listed on Table 3, the Supplement to Table 3, pages A-18 through -20, and the geologic logs for DH 84-2, -7, and -12 in the appendix. The thin wall samples discussed above were shipped to the E&R Center laboratories for testing accompanied by the memorandum dated December 11, 1984, subject, "Field Exploration Program, Clark Canyon Dam, East Bench Unit - Three Forks Division - P-SMBP, Montana."

Additional samples were attempted in various drill holes, but were damaged when the tubes were crushed in the gravely soils. Eventually, this technique was discontinued because of the inability to obtain usable samples. Physical property tests were performed by commercial laboratories in Billings, Montana, on 8 thin wall drive samples (2 in alluvial fan deposits, 1 in alluvium, and 5 in Zone 1) from DH 84-2, -7, and -12 that were disturbed during sampling. Results of these are listed on Table 3 (Sample type C), and the Supplement to Table 3, pages A-1 through -11 and -14 through -17 in the appendix. Locations and depths where the samples were collected are shown on the geologic logs for DH 84-2, -7, and -12.

Butter's Thin Wall Fixed Piston Samples

Nine Butter's thin wall fixed piston samples were obtained in Drill Holes DH 85-3A, -3B, and -11A. Six samples were from alluvial fan deposits in Drill Holes DH 85-3A and -3B, and 3 samples were in railroad fill in DH 85-11A. In-place dry densities ranged from 82.8 to 111.3 pounds per cubic foot (average 97.6 pounds per cubic foot) in the alluvial fan deposits and 74.4 to 86.5 pounds per cubic foot (79.9 pounds per cubic foot) in the railroad fill. Additional data are listed on the geologic logs for DH 85-3A, -3B, and -11A; Table 3; and the supplement to Table 3, pages A-21 through -30 in the appendix. All of the samples collected were shipped to the E&R Center's laboratory accompanied by the UM Regional Engineer's memorandum dated August 19, 1985, subject, "Transmittal of Butter's Samples From Clark Canyon Dam - Three Forks Division - Pick-Sloan Missouri Basin Program, Montana."

Core Sample

One disturbed core sample collected from the Zone 2 embankment in Drill Hole PR 85-9 was tested by commercial laboratories in Billings, Montana. Physical properties test results and additional data are listed on the geologic log for PR 85-9; Table 3 (Sample Type C); the Supplement to Table 3, pages A-12 and -13 in the appendix.

Test Pit Samples

Two in-place density (sand cone) tests were conducted in the alluvial fan materials in an area about 10 feet downstream from Drill Hole DH 84-13 (seep area in right abutment). The upper test was at a depth of 1.1 to 2.1 feet, and the lower test was at a depth of 3.1 to 4.1 feet. The materials were classified as silty clays and silts. In-place dry densities of 98.1 and 93.5 pounds per cubic foot were calculated for the upper and lower tests, respectively. Maximum dry densities were determined in the laboratories to be 107.8 pounds per cubic foot with a moisture content of 16.2 percent for the upper horizon and 112.5 pounds per cubic foot with a moisture content of 13.7 percent for the lower horizon. All sampling and testing was completed by John Thompson from the USBR's materials laboratory at Deerfield Dam. Additional data are listed on Table 3 (Sample Type FD); and the supplement to Table 3, pages A-31 through -45 in the appendix.

Additional density tests were to be done near Drill Holes DH 84-1 and PR 85-3, but saturated, unstable material in these areas complicated testing procedures. Tests at these locations were abandoned.

A surface sample (alluvial fan deposits) collected from a shallow pit in the saturated seepage area (N. 25, 832; W. 13, 904) in the right abutment was tested by commercial laboratories. Physical property results are shown on Table 3 (Sample Type TP); and the Supplement to Table 3, page A-46 in the appendix.

Because of the concern over seepage in the right abutment, a series of test pits were excavated along the right toe drain of the dam in 1984. Four samples were collected in one test pit located at drain station 9+70 (0+00 at the drain outlet near the river channel). The samples included material from the (a) Zone 2 embankment, (b) sand filter around the toe drain, (c) gravel surrounding the toe drain and filter, and (d) alluvial fan deposits beneath the drain. Gradations were performed on these samples by commercial laboratories and these are listed on Table 3 (Sample Type TP); and the Supplement to Table 3, pages A-47 through -50 in the appendix.

CONCLUSIONS

In summary, 26 porous tube piezometers (2 destroyed), 3 slotted pipes (1 destroyed), and 15 temporary observation wells were installed at Clark Canyon Dam during 1984 and 1985. In the permanent monitoring system, 7 porous tube piezometers and 1 slotted pipe were placed in the Madison Limestone; 7 porous tube piezometers were set in the Beaverhead Conglomerate (?); 1 slotted pipe and 1 porous tube piezometers were installed in alluvial deposits; 4 porous tube piezometers and 1 slotted pipe were installed in Zone 1 embankment. The 2 porous tube piezometers (Madison Limestone and Beaverhead Conglomerate) in DH 84-1 were unusable

after a mud slide severed the upper part of piezometer stand pipes. A slotted pipe placed in alluvial fan deposits in PR 84-13 was also destroyed when the drains were being installed in the right abutment seep area during late 1984. All of the 15 temporary observation wells which consisted of open ended casing bottomed either in alluvial fan deposits or the Beaverhead Conglomerate (?). Six of these wells were destroyed in late 1984 when the right abutment drains were constructed.

Detailed information on the monitoring system is described on the geologic logs for Observation Wells PR 84-1, -5, -6, -10, -10A, -11, and -13 and DH 84-2, -7, and -12 and PR 85-3, -3B, and -9 and DH 85-3A, -4, -8, and -11A, and Table 1 for Observation Wells 84-201 through -215.

In addition, 5 drill holes (DH 114, 122, 134, 140, and 141) were rehabilitated to insure that they would remain operable. This involved installing 3/4-inch-diameter plastic pipe within each well and placing a protective pipe with a locking cap around all well head assemblies. Pipe was also extended several feet in DH 140 to prevent water from flowing from the well during high reservoir periods.

Drilling and testing at the site indicated that 2 types of material were encountered that might liquefy. This was based on the assumption that liquefiable materials contain large amounts of fine sand and/or silt and that SPT tests in the deposits must be less than 20 blows per foot. The material types having these characteristics include portions of the "old" railroad fill in the river flood plain and the alluvial fan deposits in the right abutment.

The railroad fill (penetrated by PR 84-11) is linear in shape, probably composed of various materials, and would not underlie the dam over large areas.

The alluvial fan consists of clay, silt, sand, and some gravel and grades both vertically and horizontally into different types of materials. The deposit is extensive and does underlie much of the right dam abutment. Standard penetration resistance tests (SPT) conducted in this material indicate that the area above where the seep occurred did have SPT test below 20 blows per foot (PR 84-1 and 85-3); however, similar materials beneath the dam had SPT blows exceeding 20 blows per foot (PR 84-5 and -6, and 85-4 and -8). Two possible explanations for this is that (a) the weight of the dam stabilizes and compacts the deposit, and (b) the clay, silt, and sand particles may approach a "quick" condition downstream of the dam in the seep area with the particles actually being floated by hydraulic pressure. If this is true, then drainage of the seep area should help stabilize the condition.

Although low blow counts were not encountered in the river alluvium, zones in these deposits may have a potential to liquefy. These zones should be lenticular or were deposited in discontinuous channels and will not underlie the dam over large areas.

APPENDIX

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-1 Coordinates N. 25,650.3 E W. 13,801.8 Ground Elevation 5503.1' Top of Pipe 5504.4'

Depth and Elev. of Water Level* See Notes Location Approx. 200' Rt. of Dam Sta. 17+00 Total Depth 49.2'

*Date Measured See Notes Date Begun 5-8-84 Finished 5-15-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
M. Lockhart

METHOD
0 to 30.9' took 2" diameter drive samples with SPT tests at 5' intervals. Drove 4" casing as needed to prevent caving. Reamed hole. Drilled 30.9 to 33.7' with Hw core barrel and diamond bit. Drilled 33.7 to 49.2' using 3-3/4" rock bit. Water used as drill fluid.

CASING RECORD
Drove 4" casing to prevent caving.

Depth	Date
0-5.0'	5-8-84
5.0-23.3'	5-9-84
23.3-30.7'	5-10-84

Pulled casing on 5-15-84.

PROGRESS RECORD

Depth	Date
0-5.0'	5-8-84
5.0-23.3'	5-9-84
23.3-30-7'	5-10-84
30.7-41.0'	5-14-84
41.0-49.2	5-15-84

PIEZOMETERS
Set lower porous tube piezometer (A) from 46 to 44'. Sandpacked hole from 49.2 to 40'. Filled hole with bentonite balls 40 to 31'. Set upper porous tube piezometer (B) from 26 to 24'. Sandpacked hole from 31 to 21.5'. Filled hole with bentonite balls

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
75				
100				
100				
64	0*	27		
33				9.0
73	11	13		10
60				
40				
96				14.5
80	10**	19		
50				18.0
33				
43	12	14		20
100				
72				
100	35	14		
47				
38				
38				30
86	39	8		30.9
0 RB				40
				49.2
				50
				60
				70
				80
				90

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

* SPT barrel, rods, and hammer sunk 2.5' from their own weight (4.9 to 7.4')

** Driller reported very soft zone 14.5 to 18.0'.

CLASSIFICATION AND DESCRIPTION OF MATERIAL

ALLUVIUM ? - HOLOCENE (fan deposit
0.0-9.0' SANDY SILT: Approx. 60% nonplastic fines; approx. 40% very fine sand; brown 0 to 2.5'; tan 2.5 to 9.0' moist to saturated; crumbly to muddy; strong HCl reaction. (ML)

9.0-14.5' SILTY SAND WITH GRAVEL: Approx. 50% fine to coarse, subangular to subrounded, hard sand; approx. 30% fine to coarse, subangular to subrounded, hard gravel to 1-1/2" diameter; approx. 20% nonplastic fines; tan; saturated; crumbly to loose; strong HCl reaction. (SM)

14.5-18.0' SAND: Approx. 95% very fine sand, aporox. 5% nonplastic fines; tan; saturated; loose to runny; strong HCl reaction. (SP)

CONGLOMERATE ? (BEAVERHEAD FORMATION) - UPPER CRETACEOUS AND LOWER TERTIARY

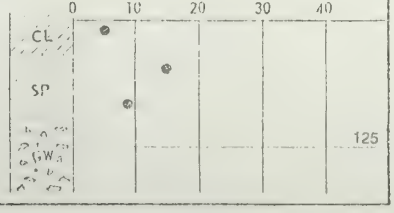
18.0-30.9' SAND AND GRAVELLY SAND: Alternating lenses of sand and gravelly sand; poor recovery in unit, but it appears to be mostly 3 to 4' thick beds of gravelly sand with 1 to 2' thick beds of fine sand. The gravelly sand is approx. 55% fine to coarse, subangular to subrounded, hard sand; approx. 40% subangular to subrounded, hard, fine to coarse gravel; approx. 5% nonplastic fines; and probably a few cobbles. (SP) The sand is approx. 95% very fine sand with approx. 5% nonplastic fines. (SP) The unit is tan with some rusty brown in the bottom foot; uncemented; loose; saturated weak to moderate HCl reaction.

MADISON GROUP-MISSISSIPPIAN
30.9-49.2' LIMESTONE: Core only from 30.9 to 33.7'. Unit is light gray; hard; oxidized; core badly broken by mostly heavily oxidized bedding planes dipping approx. 30°, and numerous irregularly dipping (mostly high angle), white, calcite filled joints; core lengths range up to 3" long.

0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT	Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot
CLASSIFICATION AND DESCRIPTION	Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)
PENETRATION RESISTANCE	Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-1 Coordinates N. 25,650.3 W. 13,801.8 Ground Elevation 5503.1' Top of Pipe 5504.4'

Depth and Elev. of Water Level* See Notes Location Approx. 200' Rt. of Dam Sta. 17+00 Total Depth 49.2'

*Date Measured See Notes Date Begun 5-8-84 Finished 5-15-84 Logged by Parish Approved by

NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH FT.	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (Weight of Hammer 140 lb., Height of Drop 30 in.) 0 10 20 30 40 50	CLASSIFICATION AND DESCRIPTION OF MATERIAL
from 21.5 to 10'. Set 4" steel protective pipe to 2' leaving 2' stick-up. Grouted with sand/cement grout from 10' to near top of 1/2" PVC piezometer pipes. Lower pipe (A) is approx. 1" shorter than upper pipe (B).					10		2.0'	STEEL PIPE
								SAND/CEMENT GROUT
							10.0'	
					20			BENTONITE
							21.5'	
								(B) 24.0-26.0'
								SAND
					30			CONGLOMERATE
							31.0'	LIMESTONE
								BENTONITE
					40		40.0	
								SAND
								(A) 44.0-46.0'
					50		49.2'	
					60			
					70			
					80			
					90			

WATER LEVELS
Lower (A)
Depth Date

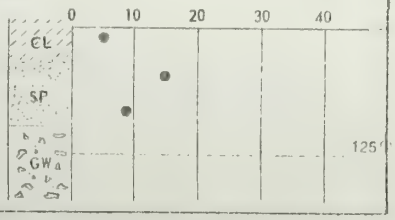
Upper (B)
Depth Date

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, tan, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



7-1337 (9-69)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Clark Canyon Dam | PROJECT: East Bench Unit | STATE: Montana

HOLE NO.: DH 84-2 | LOCATION: Approx. 8' U/S Sta. 19+00. | GROUND ELEV.: 5579.85 | DIP (ANGLE FROM HORIZ.): Vertical

COORDS: N. 25,607.1 E. W. 14,095.5

BEGUN: 9-6-84 | FINISHED: 9-10-84 | DEPTH OF OVERBURDEN: | TOTAL DEPTH: 120.6' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: Parish | LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

DRILL
Portadrill

DRILLER
Larry Thomas

METHOD
Drilled 0 to 120.6' using 7-7/8" rock-bit with air and foam to remove cuttings. Drove 8" I.D. Casing and drilled inside casing except in bedrock. Drilled "open hole" after driving casing into top of bedrock. Took 5" thinwall push tube samples at selected intervals. Set porous tube piezometers in selected zones.

CASING RECORD
Used 8" I.D. Casing to prevent caving and help alleviate fracturing within the embankment. Pulled casing on completion of the hole.

DEPTH	DATE
0-90.6'	9-6-84
90.6-108.0'±	9-7-84

PROGRESS RECORD

Depth	Date
0-90.6'	9-6-84
90.6-120.6'	9-7-84
Driller sick	9-8-84
Set Piezo-meters	9-9-84
Set Piezo-meters	9-10-84

PIEZOMETERS
Set piezometer (A) at 117.2'. Sand-packed hole from 120.6' to 111.4'. Filled hole with bentonite balls from 111.4' to 93.2'.

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, C, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING
10¾"	0				MANHOLE COVER CONCRETE 3.0		5579.5	0.3		
					SAND DRAIN 7.0					
							5557.9	22.0		
					CONCRETE					
					61.0 BENTONITE					
					66.0' SAND					
					(C) 69.0-71.0'					
					73.2'					
					BENTONITE					
					88.0'					
	100				(B) 89.0-91.0' SAND					
	0				93.2'					
					BENTONITE		5480.7	99.1		

CLASSIFICATION AND PHYSICAL CONDITION

NOTE: Material logged from rockbit cuttings and the trimmings of occasional 5" thinwall push tubes.

EMBANKMENT ?
0.0-0.3' Asphalt: Black; crumbly.
0.3-22.0' Gravel: Approx. 55% fine to coarse, hard, subangular to subrounded gravel; approx. 35% fine to coarse sand; approx. 10% nonplastic fines; moist; brown. (GP-GM)
22.0-99.1' Silty to Clayey Sand and Gravel: (Note - The basal part of this unit may contain foundation material. No definite embankment/foundation contact could be determined) Material is quite variable. Approx. 55% fine to coarse, hard subangular to subrounded gravel with approx. 25% fine to coarse sand and 20% low plasticity to nonplastic fines (GC) and (GM) -- varying to approx. 55% fine to coarse, hard sand with 25 fine to coarse, hard, subangular to subrounded gravel and 20% low plasticity to nonplastic fines (SC) and (SM). The unit also contains a few cobbles which momentarily stopped the driving of casing. The material appeared moist; compact; and usually brown in color. Occasional thin zones of dark gray, slightly organic material suggested that the borrow sources were not cleanly stripped before use.

CONGLOMERATE? (BEAVERHEAD FORMATION)-UPPER CRETACEOUS AND LOWER TERTIARY
99.1-105.6' Gravel: Approx. 75 fine to coarse, hard, subangular to subrounded gravel; approx. 20% fine to coarse, hard sand; approx. 5% nonplastic fines; saturated; loose; brown. (GP)

MADISON GROUP - MISSISSIPPIAN
105.6-120.6' Limestone: Broken and heavily oxidized (red) to about 108.0'; grading to fresh, hard, medium gray rock at depth. The driller estimated that the unit was producing approx. 10 gpm of water while blowing the hole clean at 120.6'.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Ca = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

GEOLOGIC LOG OF DRILL HOLE

FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana

HOLE NO. DH 84-2 LOCATION approx. 8' U/S Sta. 19+00

COORDS. N. 25,607.1 E. XX W. 14,095.8 GROUND ELEV. 5579.85 DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 9-6-84 FINISHED 9-10-84 DEPTH OF OVERBURDEN TOTAL DEPTH 120.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY Parish LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Ce, or Cm)	DEPTH (FEET) TO	LOSS (G P M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Set piezometer (B) at 91.0'. Sand packed hole from 93.2' to 88.0'. Filled hole with bentonite balls from 88.0' to 73.2' Set piezometer (C) at 71.0'. Sand packed hole from 73.2' to 66.0'. Filled hole with bentonite balls from 66.0' to 61.0'. Filled hole with concrete from 61.0 to 7.0'. Set drain sleeves around piezometer pipes. Filled hole with sand from 7.0 to 3.0'. Filled hole with concrete from 3.0 to surface and set manhole cover over piezometer pipes. SAMPLING Because of the coarseness of material only one thinwall sample was collected. It was completed from 90.6' to 92.5'. Attempts were made to push tubes at depths of 10.6', 20.6', 22.5', 36.5', 70.6', and 90.6'. Where sufficient material was retained in the push tubes, sack samples were collected. PRIMARY WATER PRODUCING ZONES NOTED DURING DRILLING 1. Gravel from 99.1 to 105.6'. 2. Limestone below 108.0'±. Top seemed dry, but driller estimated 10 gpm.	10 3/4"	0				BENTONITE 111.5' SAND (A) 115.5-117.2' 120.6'		5474.3 5459.3	105.6 120.6			Evaluations of top of piezometer pipes: A: 5579.4 B: 5579.5 C: 5579.6

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Ce = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana

HOLE NO. DH 84-2 LOCATION Approx. 8' U/S Sta. 19+00

COORDS. N. 25,607.1 X or E. W. 14,095.5 GROUND ELEV. 5579.85 DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 9-6-84 FINISHED 9-10-84 DEPTH OF OVERBURDEN TOTAL DEPTH 120.6' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY Parish LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
blown from hole at 120.6'. WATER LEVELS One water level was taken before the hole was completed and the piezometers installed: Depth 88.7' Date 9-7-84									10, 20, 30, 40, 50, 60, 70, 80, 90			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystalite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-85-3 Coordinates N. 25,651.4 E.W. 13,781.9 Ground Elevation 5510.2 (see * sheet 2 of 2)

Depth and Elev. of Water Level* See notes Location approx. 220' D/S Sta. 17+00 Total Depth 48.0'

*Date Measured See notes Date Begun 5-15-85 Finished 5-19-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions. Caving and other information

DRILL RIG

Failing 1500 truck-mounted.

DRILLER

J. McLaughlin

METHOD

Took Bx drive samples from 0 to 35.8' with PR's at approx. 2.5' intervals from 2.5 to 27.5'. Used 2-15/16 inch rock bit from 30.0 to 31.0 and 35.8 to 39.1'. Drilled from 39.1 to 48.0' using Nx diamond core bit.

CASING RECORD

Drove 4" casing to prevent caving and water loss.

Depth	Date('85)
0-17.5	5-16
0-30.5	5-17
0-37.0	5-18
pulled	5-19

PROGRESS RECORD

Depth	Date('85)
set-up	5-15
0-21.3	5-16
21.3-33.9	5-17
33.9-44.5	5-18
44.5-48.0	5-19
hole compl.	5-19

DRILLER'S COMMENTS

No recovery from 17.3 to 18.8' due to small gravels in barrel; didn't have checkball in and sample washed out. Limestone core samples kept blocking off. Had 100% water loss in broken limestone from 44.5 to 45.9'.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
100				
80	18	4.7		
100				
54	50/.7	4.1		
40				9.5
60	28	19.9		10.8
72				
60				
	50/.9	14.4		
100				
0	17			
80				20.8
13	5	18.2		
20				25.8
100	44	10.8		
80				
wash				30
69				
90				
wash				38.2
64				40
100				
100				
100				
57				
100				
77				48.0
				50
				60
				70
				80
				90

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

63
56

CLASSIFICATION AND DESCRIPTION OF MATERIAL

FILL

0.0-9.5' SANDY GRAVEL: approx. 60% fine to coarse, hard, sub-rounded to subangular gravel; approx. 35% fine to coarse, hard sand; approx. 5% nonplastic fines. Light brown to tan; dry; crumbly; moderate to strong HCl reaction. (GP)

ALLUVIUM-HOLOCENE (Fan deposit)

9.5-10.8' SANDY SILT: approx. 60% nonplastic fines; approx. 40% fine sand. Brown; moist; soft; moderate to strong HCl reaction. (ML)

10.8-20.8' SILTY SAND WITH GRAVEL: approx. 50% fine to coarse, hard sand; approx. 35% fine to coarse, subangular to subrounded, hard gravel; approx. 15% nonplastic fines. Brown to tan; moist; loose; moderate HCl reaction (SM)

20.8-25.8' SILTY SAND: approx. 85% fine to medium sand; aprox. 15% nonplastic fines; tan; moist; loose; moderate to strong HCl reaction. (SM)

CONGLOMERATE(?) (BEAVERHEAD FORMATION) - UPPER CRETACEOUS AND LOWER TERTIARY

25.8-38.2' SILTY SAND WITH GRAVEL: approx. 50% fine to coarse, hard sand; approx. 40% fine to coarse, hard, subangular gravel; approx. 10% nonplastic fines. Locally variable with greater percentage (60 to 70%) of sand in lenses. Tan to orange; weakly cemented; strong HCl reaction. (SP-SM to SP)

MADISON GROUP - MISSISSIPPIAN

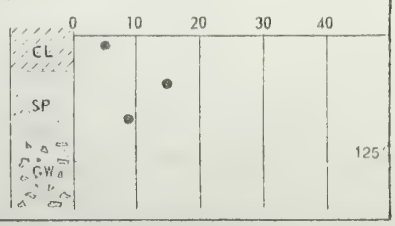
38.2-48.0' LIMESTONE: Light gray; hard (H-3); oxidized; badly broken along approx. 30° bedding planes, with numerous, irregular white calcite-filled joints; core lengths less than 0.5' in length.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR-85-3

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-85-3 Coordinates N. 25,651.4 W. 13,781.9 Ground Elevation 5510.2*

Depth and Elev. of Water Level* See notes Location approx. 220' D/S Sta. 17+00 Total Depth 48.0'

*Date Measured See notes Date Begun 5-15-85 Finished 5-19-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

CORE RECOVERY-%

BLOWS/FOOT

WATER CONTENT-%

SAMPLES FOR TESTING

DEPTH (FT.)

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

CLASSIFICATION AND DESCRIPTION OF MATERIAL

PIEZOMETERS

Set lower porous tube piezometer (A) from 44.9 to 46.9' with silica sand sandpack from 40.0 to 48.0'. Filled hole with bentonite balls from 34.8 to 40.0'. Set upper porous tube piezometer (B) from 30.0 to 32.0' with silica sand sandpack from 28.1 to 34.8'. Filled hole with bentonite balls from 23.0 to 28.1' and grouted out hole from 0 to 23.0'. Used 3/4" PVC on piezometers. Set protective steel pipe 3.0' in ground with a 7.0' stickup.

WATER LEVELS
During Drilling:

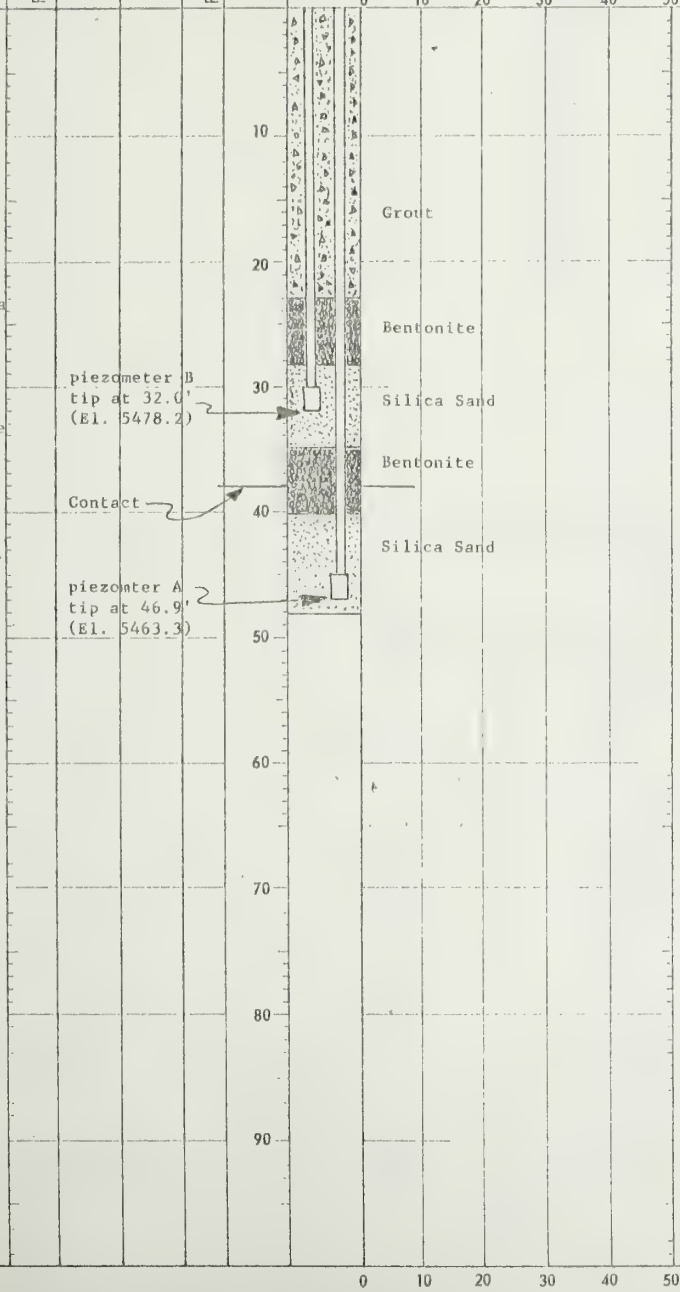
Depth	Date ('85)
dry	5-16
8.0	5-17
8.1	5-18
7.7	5-19

PIEZOMETER A

DEPTH	DATE
12.0	6-17-85
17.0	7-17-85
18.8	7-30-85

PIEZOMETER B

Depth	Date
12.0	6-17-85
17.2	7-17-85
18.8	7-30-85



0 10 20 30 40 50

* Piezometer pipes were extended above this elevation after drilling in order to overcome possible future high water artesian head.

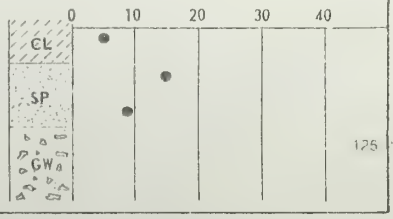
Piezometer A pipe was extended 4.2 feet above original ground (top of pipe at elevation 5514.4) and piezometer B pipe was extended 4.3 feet above original ground (top of pipe at elevation 5514.4). Consequently, final piezometer "depths" are 36.3 and 51.1 feet respectively, for piezometers B and A.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR-85-3

7-1337 (9-69)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 2

FEATURE: Clark Canyon Dam — PROJECT: East Bench Unit — STATE: Montana

HOLE NO.: DH 85-3A — LOCATION: approx. 210' D/S Sta. 17+00 — COORDS. N. 25,646.3 X W. 13,783.2 — GROUND ELEV. 5507.8 — DIP (ANGLE FROM HORIZ.) 90°

BEGUN: 5-20-85 — FINISHED: 5-29-85 — DEPTH OF OVERBURDEN 23.5' — TOTAL DEPTH 27.0' — BEARING: --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See notes below — LOGGED BY: F. Calcagno Jr. — LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

DRILL RIG

Failing 1500 truck-mounted.

DRILLER

J. McLaughlin

METHOD

Bx drive sample from 0 to 4.8'. Piston-type Butter's Samples from 5.3 to 6.8 and 6.80 to 8.3'. Attempted Butter Samples from 22.0 to 23.1, but lost sample due to rock. Used 2-15/16 rock bit from 4.8 to 5.3, 8.3 to 22.0, and 23.1 to 27.0.

CASING RECORD

Drove 4" casing to prevent caving and water loss.

Depth	Date('85)
0-4.5	5-20
0-20.5	5-21
pulled	5-29

PROGRESS RECORD

Depth	Date('85)
setup	5-20
0-4.8	5-20
4.8-20.4	5-21
Away from	5-22to
site	5-29
20.4-27.0	5-29
Hole compl.	5-29

HOLE COMPLETION

Pulled casing and grouted hole from 0 to 27.0'.

DRILLER'S COMMENTS

Pilot hole (DH 85-3) indicated a soft zone from 20.8 to 25.8'.

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH FROM (Ft. Cs. or Cm)	PERCOLATION TESTS: DEPTH TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Bx drive	100						5503.0	4.8			FILL
Butter	93-100						5499.5	8.3			0.0-4.8' SILTY SAND WITH GRAVEL: approx. 45% fine to coarse, hard sand; approx. 30% fine to coarse, hard, subangular to subrounded gravel; approx. 25% nonplastic fines; tan; moist to dry; moderate to strong HCl reaction. (SM)
2 15/16 inch rock bit	0						5495.7	12.1			ALLUVIUM-HOLOCENE (Fan deposit)
Butter	0						5491.8	16.1			4.8-8.3' SILTY SAND TO SANDY SILT: approx. 55% predominently fine to medium hard sand; approx. 45% nonplastic fines; trace occasional fine gravel; light brown; moist; moderate to weak HCl reaction. (SM-ML)
Core bit	0						5487.4	20.2			8.3-12.1' SANDY SILT WITH GRAVEL: approx. 50% nonplastic fines; approx. 25% predominently fine to coarse hard sand; approx. 25% fine to coarse, hard subrounded gravel; light brown; moist; weak to moderate HCl reaction. (ML)
							5484.3	23.5			12.1-16.0' SAND AND GRAVEL: approx. 50% fine to coarse, hard sand; approx. 45% fine to coarse, hard, subrounded to subangular gravel; approx. 5% nonplastic fines; tan; moist; weak HCl reaction. (SP-GP)
							5480.8	27.0			16.0-20.4' SILTY SAND: approx. 85% predominently fine to medium sand; approx. 15% nonplastic fines; tan; moist; weak HCl reaction. (SM)
											20.4-23.5' SILTY SAND WITH GRAVEL: approx. 50% fine to coarse, hard sand; approx. 30% fine to coarse, hard, subangular to subrounded gravel; approx. 20% nonplastic fines; tan to brown; moist; weak HCl reaction. (SM)
											CONGLOMERATE?- (BEAVERHEAD FORMATION) - UPPER CREACEOUS AND LOWER TERTIARY
											23.5-27.0' SILTY SAND WITH GRAVEL: approx. 50% fine to course, hard sand; approx. 40% fine to coarse, hard, subangular gravel; approx. 10% nonplastic fines. Locally variable with greater percentage (60%) of sand in lenses. Tan to orange; weakly cemented; moderate to strong HCl reaction. (SP-SM to SP)

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ..... D = Diamond, H = Hoystelite, S = Auger Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation

GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Clark Canyon Dam — PROJECT: East Bench Unit — STATE: Montana

HOLE NO.: DH 85-3A — LOCATION: approx. 210' D/S Sta. 17+00 — GROUND ELEV.: 5507.8 — DIP (ANGLE FROM HORIZ.): 90°

COORDS. N. 25,646.3 E. W. 13,783.2

BEGUN: 5-20-85 — FINISHED: 5-29-85 — DEPTH OF OVERBURDEN: 23.5' — TOTAL DEPTH: 27.0' — BEARING: -

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See notes below — LOGGED BY: F. Calcagno Jr. — LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
While advancing to 20.4', we went through a soft zone unexpectedly from 16.0 to 20.4' when casing penetrated zone on its own. We cleaned out hole to 22.0' and attempted a Butter Sample, but too mcuh gravel (no recovery). We advanced hole to 27.0 feet to try to find more soft zones but found only gravelly material. WATER LEVELS None taken TESTING Took two piston-type Butter's Samples from 5.3 to 6.8 and 6.8 to 8.3. Moisture contents in percent are: 6.76-6.77': 22%; 8.23-8.33': 21.8%, respectively.												

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/0", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

SUBSURFACE EXPLORATION · PENETRATION RESISTANCE AND LOG

Feature: Clark Canyon Dam | Project: East Bench Unit | State: Montana

Hole No. PR- DH 85-3B | Coordinates N. 25,652.6 W. 13,775.8 | Ground Elevation 5510.3

Depth and Elev. of Water Level* None taken | Location approx. 200' D/S Sta. 17+00 | Total Depth 23.4

*Date Measured None taken | Date Begun 7-24-85 | Finished 7-26-85 | Logged by F. Calcagno | Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL RIG

Failing 1500 truck mounted.

DRILLER

J. McLaughlin

METHOD

3-7/8-inch rock bit from 0 to 6.1; 9.0 to 16.2; and 16.3 to 18.0'. Piston-type Butter's samples from 6.1 to 9.0'; 16.2 to 16.3' and 18.0 to 21.9'. Penetration resistance test from 21.9 to 23.4'.

CASING RECORD

Drove 4-in. casing to prevent caving and water loss.

Depth	Date ('85
0-6.2	7-24
0-18.0	7-25
pulled	7-26

PROGRESS RECORD

Depth	Date ('85
0-7.1	7-24
7.1-23.4	7-25
Hole compl.	7-26

DRILLER'S COMMENTS

Attempted Butter's sample at 6.1' and latch locked on bar after 0.5' penetration (no sample). Other Butter's samples were very hard to push. Tried Butter's sample at 16.2' and would only penetrate 0.15' with over 300 psi.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
WASH				0
100				4.3
74				9.4
WASH				10
				14.6
wash				16.8
100				17.5
100	25	22.0		20
				23.4
				30
				40
				50
				60
				70
				80
				90

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

GRAPHIC LOG

CLASSIFICATION AND DESCRIPTION OF MATERIAL

FILL

0.0-4.3' SILTY SAND WITH GRAVEL approx 45% fine to coarse, hard sand; approx. 30% fine to coarse, hard, subangular to subrounded gravel; approx. 25% nonplastic fines; tan to brown; moist to dry; moderate to strong HCl reaction. Maximum size: 3-inch (SM)

ALLUVIUM-HOLOCENE (fan deposit)

4.3-9.4' SILTY SAND: approx. 60% fine to medium, hard sand; approx 40% nonplastic fines; tan; moist; weak to moderate HCl reaction. Maximum size: #30. (SM)

9.4-14.6' SILTY SAND WITH GRAVEL: approx. 40% fine to coarse, hard sand; approx. 35% fine to coarse, hard, subangular to subrounded gravel; approx. 25% nonplastic fines; tan; moist. Maximum size: 3-inch. (SM)

14.6-16.8' SAND: approx. 95% predominantly fine to medium sand; approx. 5% nonplastic fines; tan; moist; weak HCl reaction. Maximum size: #30 (SP)

16.8-17.5' SANDY GRAVEL: approx. 50% fine to coarse; hard; subangular to subrounded gravel; aprox. 45% fine to coarse sand; approx. 5% nonplastic fines; brown to tan; moist; weak to moderate HCl reaction. Maximum size: 4-inch. (GP-SP)

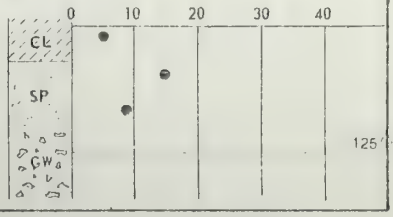
17.5-34.5' SILTY SAND: approx. 85% predominantly fine to medium sand; approx. 15% nonplastic fines; tan; moist to wet; weak HCl reaction. Maximum size: #30. (SM)

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-3B Coordinates N. 25,652.6 E W. 13,775.8 Ground Elevation 5510.3

Depth and Elev. of Water Level* None Taken Location approx. 200' D/S Sta. 17+00 Total Depth 23.4

*Date Measured None Taken Date Begun 7-24-85 Finished 7-26-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

HOLE COMPLETION

Pulled casing and grouted hole from 0 to 23.4'.

TESTING

Took four Butter's samples at: 6.6-7.1; 7.1-9.0; 18.0-19.8; and 19.8-21.9'. Moisture contents respectively are: 18.3, 15.3, 24.0, and 18.2%.

CORE RECOVERY-%

BLOWS/FOOT

WATER CONTENT-%

SAMPLES FOR TESTING

DEPTH (FT.)

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer _____ lb.
Height of Drop _____ in.

0 10 20 30 40 50

CLASSIFICATION AND DESCRIPTION OF MATERIAL

10 20 30 40 50 60 70 80 90

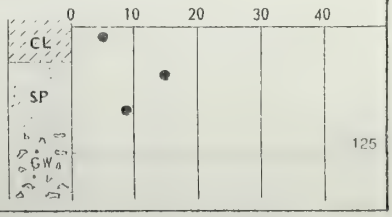
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- DH 85-3B

GPO 838-002

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-4 Coordinates N. 25,663.6 E W. 14,039.2 Drill Platform Excavation Elevation 5546.5 (See * Sheet 2 of 2)

Depth and Elev. of Water Level* See notes Location approx. 70' D/S Sta. 19+00 Total Depth 86.1

*Date Measured Date Begun 6-26-85 Finished 7-11-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL RIG

Sprague and Henwood 140CL Skid rig.

DRILLER

J. McLaughlin

METHOD

Bx drive from 0 to 71.0' and 72.1 to 77.9', with penetration tests as shown at right. Used 2-15/16" rock bit from 71.0 to 72.1' and 77.9 to 86.1'. Attempted thin wall sample at 64.7' (could not push) to 66.1'. Water used as a drill fluid.

CASING RECORD

4-inch casing to prevent caving and water loss.

Depth	Date('85
0-10.5	6-27
0-35.5	6-28
0-50.5	6-29
0-65.5	6-30
0-70.5	7-1
0-77.5	7-2
pulled	7-11

PROGRESS RECORD

Depth(ft)	Date('85
set up	6-26
0-15.0	6-27
15.0-35.0	6-28
35.0-50.0	6-29
50.0-65.0	6-30
65.0-71.0	7-1
71.0-86.1 hole completion	7-2 to 7-11

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING
100			
100			
80			
100			
100			
100			
100			
30	26	8.9	
100	45	22.4	
76			
87			
100			
80			
70			
68			
29			
60	27	17.8	
80			
0			
W			
45			
69			
W			

DEPTH (FT.): 10, 20, 28.0, 30, 39.0, 40, 50, 60, 63.5, 70, 74.5, 77.9, 80, 86.1, 90

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

CLASSIFICATION AND DESCRIPTION OF MATERIAL

EMBANKMENT

0.0-28.0' GRAVEL (ZONE 2): approx. 55% fine to coarse, hard, subangular to subrounded gravel; approx. 35% fine to coarse sand; approx. 10% nonplastic fines; tan; dry. Moderate to strong HCl reaction. Maximum size: 3-inch. (GP-GM)

-Locally clayey sand with gravel zones (approx. 50% fine to coarse sand; approx. 30% low to no plasticity fines; approx. 20% fine, hard gravel) at the following depths:

5.0-5.5
10.0-10.8
14.0-16.0
18.4-19.0
25.9-26.2

28.0-39.0' CLAYEY SAND (ZONE1): approx. 50% fine to predominently coarse sand; approx. 35% low plasticity fines; approx. 15% fine, hard, subrounded to subangular gravel; tan to brown; dry; high dry strength. Moderate to weak HCl reaction. Maximum size: 2-inch. (SC-SM)

39.0-63.5' GRAVEL (ZONE2): approx. 55% fine to coarse, hard, subangular to subrounded gravel; approx. 35% fine to coarse sand; approx. 10% nonplastic fines; tan; moist to dry. Moderate HCl reaction. Maximum size: 3-inch. (GP-GM)

-Locally clayey sand with gravel zones (approx. 50% sand; approx. 30% low to no plasticity fines; approx. 20% fine, hard gravel) at:

40.8-41.2
52.0-54.3

-Locally sandy zone (approx. 65% predominantly fine to coarse sand; approx. 30% fine to coarse, hard gravel; approx. 5% nonplastic fines) at:

56.6-59.4

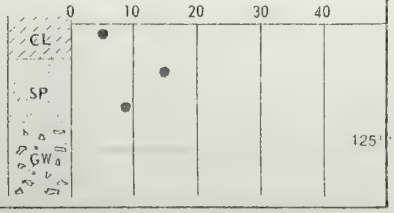
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR- DH 85-4

GPO 838.002

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-4 Coordinates N. 25,663.6 E. W. 14,039.2 Drill Platform Excavation Control Elevation 5546.5*

Depth and Elev. of Water Level* See notes Location approx. 70' D/S Sta. 19+00 Total Depth 86.1

*Date Measured See notes Date Begun 6-26-85 Finished 7-11-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILLER'S COMMENTS
Took no PR's from 0 to 35' because it was too gravelly. Drive barrel got hung up in hole from 55.0 to 60.0' (rock fell in above it). Tried a 3" push sample from 64.7 to 66.1' to see if it would push and it wouldn't; the rig came off the blocks. Broke drive hammer pin when driving casing to 77.5'

PIEZOMETERS
Sealed off bedrock with bentonite from 77.5 to 86.1'. Set lower porous tube piezometer (A) from 74.5 to 76.5' with silica sand pack from 73.5 to 77.5'. Sealed hole between piezometers with bentonite from 63.0 to 73.5'. Set upper porous tube piezometer (B) from 60.0 to 62.0' with silica sandpack from 59.0 to 63.0'. Sealed upper part of hole with bentonite from 27.0 to 59.0'; dirty, sand from 26.0 to 27.0', and grout from 0 to 26.0'.

WATER LEVELS

LOWER PIEZOMETER (A)	
69.9	7-17-85
70.5	7-30-85
UPPER PIEZOMETER (B)	
dry	7-17-85
dry	7-30-85

CORE RECOVERY-%

BLOWS/FOOT

WATER CONTENT-%

SAMPLES FOR TESTING

DEPTH (FT.)

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer _____ lb.
Height of Drop _____ in.
0 10 20 30 40 50

Piezometer (B) tip at 62.0' (El. 5484.5)

Piezometer (A) tip at 76.5'. (El. 5470.0)

Grout

Dirty Sand

Bentonite

Silica Sand

foundation contact

Bentonite

Silica Sand

Bedrock contact

Bentonite

CLASSIFICATION AND DESCRIPTION OF MATERIAL

ALLUVIUM-HOLOCENE (fan deposit)

63.5-69.7' SILTY SAND WITH GRAVEL: approx. 75% fine to medium sand; approx. 15% nonplastic fines; approx. 10% fine, hard, subrounded gravel; tan; moist. Maximum sand size: #30. Maximum size: 1-inch. Weak to moderate HCl reaction. (SM)

69.7-74.5' SAND AND GRAVEL: approx. 75% fine to medium sand; approx. 20% fine, hard, subrounded gravel; approx. 5% nonplastic fines; brown; moist; weak HCl reaction. Maximum size: 1/2 -inch. (SP)

CONGLOMERATE(?) BEAVERHEAD FORMATION - UPPER CRETACEOUS AND LOWER TERTIARY

74.5-77.9' CLAYEY GRAVEL: approx. 40% fine to coarse, hard, angular, limestone gravel; approx. 30% fine to coarse, hard, subangular sand (limestone particles) oxidized orange-red; moist. Moderate to strong HCl reaction. Maximum size: 2-inch. (Decomposed limestone) (GC)

MADISON GROUP - MISSISSIPPIAN

77.9-86.1' LIMESTONE: Light gray to oxidized orange. Core recovered as wash samples.

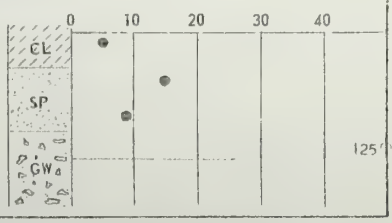
*Piezometer pipes were extended above this elevation after drilling and the drill platform excavation was backfilled. Piezometer A was extended 7.5 feet above the platform (top of pipe at elevation 5554.0) and Piezometer B pipe was extended 7.6 feet above the platform (top of pipe at elevation 5554.1). Consequently, final piezometer "depths" are 69.6 and 84.0 feet respectively for piezometers B and A.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR- DH 85-4

GPO 838-962

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-5 Coordinates N. 25,779.8 W. 13,974.8 Ground Elevation 5502.4±

Depth and Elev. of Water Level* See Notes Location approx. 200' D/S Sta. 19+00 Total Depth 32.3'

*Date Measured See Notes Date Begun 10-17-84 Finished 11-4-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
J. McLaughlin

METHOD
Drilled 0 to 31.3' using 8x casing drive samples with rockbit wash samples in rocky zones. Took S.P.T. tests at 2-1/2' intervals where possible. Drilled from 31.3' to 32.3' using 2-15/16" rockbit. Water used as drill fluid.

CASING RECORD
Set 4" casing to prevent caving.

Depth	Date
0-15.0'	10-18-84
15.0-32.0'	10-19-84
Pulled Casing	11-04-84

PROGRESS RECORD

Depth	Date
0-1.0'	10-17-84
1.0-14.1'	10-18-84
14.1-31.1'	10-19-84
31.1-32.3'	11-03-84

PIEZOMETERS
Set piezometer (A) from 28.8' to 30.8'. Sandpacked from 32.3' to 25.5'. Filled hole with bentonite balls from 25.5' to 16.0'. Set piezometer (B) from 14.0' to 12.0'. Sandpacked from 16.0' to 10.4'. Filled hole with bentonite balls from 10.4' to 3.0'. Concreted in 4" steel protective pipe from 3.0' to surface. Approx. 2' stickup.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
40				
100	50/.2	11.3		
100				
8				
53	46	9.5		
100				
47	38	10.9		9.0
100				10
64	50/.6	7.9		
100				
13	29	*		18.0
0				
34	50/.3	*		20
90				
67	50/.8	11.8		24.6
100				
0				
47	32	*		
52				30
50	50/.2	*		31.1
0				32.3

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

250 83 167 63 250

NOTE: Soft zone from 18.0' to 24.6' affected by rocks in the S.P.T. barrel.

CLASSIFICATION AND DESCRIPTION OF MATERIAL

EMBANKMENT
0.0-9.0' Clayey Gravel: Approx. 50% fine to coarse, hard, mostly angular to subangular, gray limestone gravel; approx. 30% fine to coarse, hard sand; approx. 20% low plasticity fines; loose to crumbly; strong HCl reaction; brown. (GC)

9.0-18.0' Sand: Approx. 55% fine to coarse, hard sand; approx. 35% fine to coarse, hard, subangular to subrounded gravel; approx. 10% nonplastic fines; loose; strong HCl reaction; brown. (SP-SM)

ALLUVIUM-HOLOCENE (fan deposit)
18.0-24.6' Silty Sand: Approx. 85% fine sand; approx. 15% nonplastic fines; occasional mostly fine gravels; soft; strong HCl reaction; brown. (SM)

CONGLOMERATE?-(BEAVERHEAD FORMATION)-UPPER CRETACEOUS AND LOWER TERTIARY
24.6-31.1' Clayey Gravel: Approx. 50% fine to coarse, hard, subangular to subrounded gravel; approx. 30% fine to coarse, hard sand; approx. 20% low plasticity fines; crumbly; strong HCl reaction; brown (GC)

MADISON GROUP - MISSISSIPIAN
31.1-32.3' Limestone: Hard; gray; fractured.

Elevations of top of piezometer pipes:

A: 5504.5
B: 5504.6

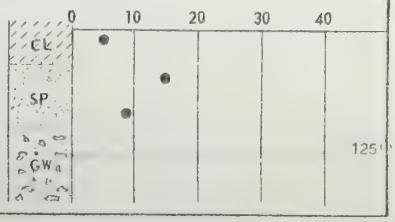
* No reliable moisture test.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR-84-5

7-1394 (9-71)
Bureau of Reclamation

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-5 Coordinates N. 25,779.8 XXXXX W. 13,974.8 Ground Elevation 5502.4±

Depth and Elev. of Water Level* See Notes Location approx. 200' D/S Sta. 19+00 Total Depth 32.3'

*Date Measured See Notes Date Begun 10-17-84 Finished 11-4-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

WATER LEVELS
Depth Date

CORE RECOVERY-% | BLOWS/FOOT | WATER CONTENT-% | SAMPLES FOR TESTING | DEPTH (FT.) | GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

CLASSIFICATION AND DESCRIPTION OF MATERIAL

DEPTH (FT.)	
0	4" STEEL PIPE CONCRETE
	BENTONITE
10.4	SAND (B) 12.0'-14.0'
16.0	BENTONITE
25.5	SAND (A) 28.8'-30.8'
32.1	
40	
50	
60	
70	
80	
90	

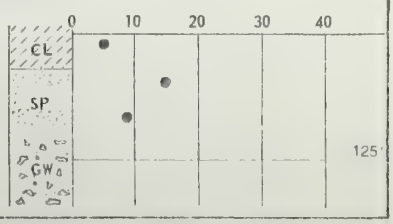
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR-84-5

GPO 838-003

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-6 Coordinates N. 25,954.8 W. 13,846.5 Ground Elevation 5485.4' Top of Pipe 5487.0'

Depth and Elev. of Water Level* See Notes Location Approx. 400' Rt. of Dam Sta. 19+00 Total Depth 30.6'

*Date Measured See Notes Date Begun 5-15-84 Finished 5-17-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
M. Lockhart

METHOD
0 to 9.3' took 2" diameter drive samples with SPT test at 5.0 to 6.0' Another SPT test at 9.0 to 10.0' was stopped by gravel. Drove 4" casing as needed to prevent caving. Reamed hole and drilled 9.3 to 12.8' with 3-3/4" diameter rock bit. Took 2" diameter drive sample from 12.8 to 14.8'. Drilled 14.8 to 22.1' with Nx diamond core barrel. Drilled 22.1 to 30.6' with 2-3/4" diameter rockbit. Water used as drill fluid.

CASING RECORD
Drove 4" casing 0 to 14.8' on 5-16-84. Pulled casing 5-17-84.

PROGRESS RECORD

Depth	Date
0-6.4'	5-15-84
6.4-22.1'	5-16-84
22.1-30.6'	5-17-84

PIEZOMETERS
Set lower porous tube piezometer (A) from 26 to 28'. Sand packed hole from 30.6 to 22! Filled hole with bentonite balls from 22 to 10'. Set upper porous tube piezometer (B) from 6 to 8'. Sand packed hole from 10 to 4'. Filled

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING
100			
100			
100			
100	20	*	
53			
77			
0			
RB			
50			
93			
87			
0			
RB			

DEPTH (FT.): 3.5, 6.0, 10, 13.0, 20, 30, 30.6, 40, 50, 60, 70, 80, 90

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

Refusal

CLASSIFICATION AND DESCRIPTION OF MATERIAL

ALLUVIUM ? - HOLOCENE (fan deposit
0.0 - 3.5' SANDY SILT: Approx. 60% nonplastic fines; approx. 40 very fine sand; light brown; wet to saturated; crumbly to soft; strong HCl reaction. (ML)

3.6-6.0' SILTY SAND WITH GRAVEL: Approx. 60% predominantly fine sand; approx. 20% fine to coar , hard, subangular to subrounded gravel; approx. 20% nonplastic fines; tan; saturated; soft; strong HCl reaction. (SM)

CONGLOMERATE ? (BEAVERHEAD FORMATION) - UPPER CRETACEOUS AND LOWER TERTIARY

6.0-13.0' GRAVEL: Approx. 75% fine to coarse, hard, subangular to subrounded gravel; approx. 20% fine to coarse, hard, subangular to subrounded sand; approx. 5% nonplastic fines; tan to light brown; saturated; loose; strong HCl reaction. (GP)

MADISON GROUP - MISSISSIPPIAN
13.0-30.6' LIMESTONE: Core only from 13.0 to 22.1'. Unit is light gray; oxidized; core badly broken by heavily oxidized bedding planes dipping approx. 40°, and irregularly dipping (mostly high angle), white calcite filled joints; core lengths range up to 6" long.

Elevations of top of piezometer pipes:

A: 5486.9
B: 5487.0

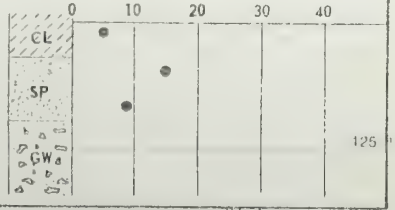
* No reliable moisture test.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR-84-6

GPO 818-002

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-6 Coordinates N. 25,954.8 E. 13,846.5 Ground Elevation 5485.4' Top of Pipe 5487.0'

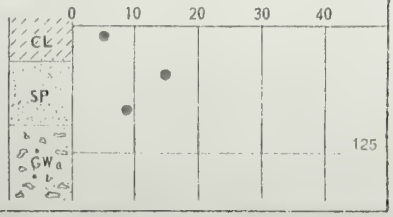
Depth and Elev. of Water Level* See Notes Location Approx. 400' Rt. of Dam Sta. 19+00 Total Depth 30.6'

*Date Measured See Notes Date Begun 5-15-84 Finished 5-17-84 Logged by Parish Approved by

NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/ FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (Weight of Hammer 140 lb., Height of Drop 30 in.) 0 10 20 30 40 50	CLASSIFICATION AND DESCRIPTION OF MATERIAL
hole with bentonite balls from 4 to 3'. Set 4" steel protective pipe to 2' leaving 2' of stickup. Grouted with sand/ cement grout from 3' to near top of PVC piezometer pipes. Lower pipe (A) is approx 1" shorter than upper pipe (B). WATER LEVELS Lower (A) Depth Date Upper (B) Depth Date					10 20 30 40 50 60 70 80 90		2.0' STEEL PIPE 3.0' SAND/CEMENT GROUT 4.0' BENTONITE (B) 6.0-8.0' 10.0' SAND CONGLOMERATE LIMESTONE BENTONITE 22.0' SAND (A) 26.0-28.0' 30.6	

EXPLANATION

BLOWS/FOOT	Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot
CLASSIFICATION AND DESCRIPTION	Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)
PENETRATION RESISTANCE	Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125O



7-1337 (8-60) Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Clark Canyon Dam | PROJECT: East Bench Unit | STATE: Montana

HOLE NO.: DH 84-7 | LOCATION: approx. 8' U/S Sta. 24+50 | GROUND ELEV.: 5579.83 | DIP (ANGLE FROM HORIZ.): Vertical

COORDS: N. 25,931.7 W. 14,539.8

BEGUN: 9-14-84 | FINISHED: 9-20-84 | DEPTH OF OVERBURDEN: | TOTAL DEPTH: 158.0' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: Parish | LOG REVIEWED BY:

DRILL
Portadrill

DRILLER
Larry Thomas

METHOD
Drilled 0 to 158.0' using 7-7/8" rock-bit and air to remove cuttings. Drove 8" I.D. casing and drilled inside casing except in bedrock. Drilled "open hole" after driving casing into top of bedrock. Took 5" thinwall push tube samples at selected intervals. Set porous tube piezometers in selected zones.

CASING RECORD
Used 8" I.D. casing to prevent caving and help alleviate fracturing within the embankment. All casing was pulled during installation of piezometers.

Depth	Date
0-30.6'	9-14-84
30.6-100.6'	9-15-84
100.6-125.6'	9-16-84
125.6-147.0'±	9-17-84

PROGRESS RECORD

Depth	Date
0-31.1'	9-14-84
31.1-100.6'	9-15-84
100.6 - 127.8'	9-16-84
127.8 - 158.0'	9-17-84

Set piezometers and manhole 9-18 through 9-20-84.

PIEZOMETERS
Set piezometer (A) at 157.6'. Sand-

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
	10 3/4"					MANHOLE COVER			0.3			
						CONCRETE		5579.5				
						3.0						
						SAND DRAIN						
						8.0						
		0				CONCRETE						
						58.0'						
		100				BENTONITE						
						65.5'						
						(C) 67.8-69.8'						
						SAND						
						73.5'						
		0				BENTONITE						

NOTE: Material logged from rotbit cuttings and the trimmings of 5" thinwall push tubes.

EMBANKMENT

0.0-0.3' Asphalt: Black; crumbly.

0.3-116.0' Clayey Sand: Approx. 55% fine to coarse, hard sand; approx. 20% fine to coarse, hard, subangular to subrounded gravel; occasional small cobbles; approx. 25% low plasticity fines; compact; moist; brown with a few thin gray, slightly organic zones. (SC)

ALLUVIUM--HOLOCENE*

116.0-121.0' Sand: Approx. 95% fine sand; approx. 5% nonplastic fines; saturated; runny; brown. (SP)

121.0-134.0' Clayey Sand: Approx. 60% fine to coarse, hard sand; approx. 20% fine to coarse, hard, subangular to subrounded gravel; approx. 20% low plasticity fines; moist to wet; brown. (SC) Contains possible thin zones of (GC).

134.0-136.0' Sand or Silty Sand: No recovery; casing drove very easily; sample fell out of 5" thinwall push tube. Muddy samples from hole cleanout appeared to be (SP) to (SM). The material was fine grained; saturated; and brown.

136.0-138.0' Clayey Sand: Poor recovery was very muddy; it appeared to be clayey sand with some gravel; saturated; brown. (SC)

138.0-145.3' Gravel: Approx. 95% fine to coarse, hard, subangular to subrounded gravel; approx. 5% nonplastic fines; saturated; loose; brown; contains many red quartzite and gray limestone fragments. (GP)

MADISON GROUP - MISSISSIPPAN

145.3-158.0' Limestone: Fresh; hard; medium gray; driller measured approx. 12 gpm. water production at 158.0' with casing set at 147.0'±.

*Alluvial contact propably lies at 127.0'. (Embankment material from 116.0 to 134.0 was wet to saturated and appeard significantly different from overlying embankment in the field.)

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8" Ax = 1-1/8" Bx = 1-5/8" Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation

GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 3

FEATURE: Clark Canyon Dam | PROJECT: East Bench Unit | STATE: Montana

HOLE NO.: DH 84-7 | LOCATION: Approx. 8' U/S Sta. 24+50 | GROUND ELEV.: 5579.83 | DIP (ANGLE FROM HORIZ.): Vertical

COORDS. N. 25,931.7 E. W. 14,539.8

BEGUN: 9-14-84 | FINISHED: 9-20-84 | DEPTH OF OVERBURDEN: | TOTAL DEPTH: 158.0' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: Parish | LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
packed hole from 158.0' to 149.4'. Filled hole with bentonite balls from 149.4' to 140.8'. Set piezometer (B) at 140.4'. It was supposed to be at 138.0', but fell lower when driving casing back. Sand packed hole from 140.8' to 136.0'. Filled hole with bentonite balls from 136.0' to 73.5'. (Suspect that sand ran into hole between 120.9' and 114.0' while casing was pulled in middle of runny sand zone.) Set piezometer (C) at 69.8'. Sandpacked hole from 73.5' to 65.5'. Filled hole with bentonite balls from 65.5' to 58.0'. Filled hole with concrete from 58.0' to 8.0' Set drain sleeves on piezometer pipes. Filled hole with drain sand from 8.0' to 3.0'. Filled hole with concrete from 3.0' to surface and set manhole cover over piezometer pipes. SAMPLING Three 5" diameter thinwall samples were completed at depths of 60.6' to 62.25', 120.6' to 121.6', and 125.6' to 127.8'. Attempts were made to push tubes at 30.6', 90.6', and 135.6'. Where sufficient material was retained in the	10 3/4"	0 100 0 100 0				BENTONITE 136.0 SAND (B) 138.4-140.4' 140.8 BENTONITE 149.4 SAND (A) 155.6-157.6' 158.0		5463.8 5458.8 5445.8 5443.8 5441.8 5434.5 5421.8	116.0 121.0 134.0 136.0 138.0 145.3 158.0			Elevations of top of piezometer pipes: A: 5579.3 B: 5579.4 C: 5579.5

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole	D = Diamond, H = Haystellite, S = Shot, C = Churn		
Hole sealed	P = Packer, Cm = Cemented, Cs = Bottom of casing		
Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE: Clark Canyon Dam PROJECT: East Bench Unit STATE: Montana

HOLE NO.: DH 84-7 LOCATION: Approx. 8' U/S Sta. 2A+50

COORDS.: N. 25,931.7 E. W. 14,539.8 GROUND ELEV.: 5579.83 DIP (ANGLE FROM HORIZ.): Vertical

BEGUN: 9-14-84 FINISHED: 9-20-84 DEPTH OF OVERBURDEN: TOTAL DEPTH: 158.0' BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes LOGGED BY: Parish LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
push tubes, sack samples were collected. PRIMARY WATER PRODUCING ZONES NOTED DURING DRILLING 1. Clayey Sand from 60.6' to 62.3'. (Small quantity, but only zone in the upper embankment that appeared to be saturated.) 2. Sand from 116.0' to 121.0'. 3. Sand? from 134.0' to 136.0' 4. Gravel from 138.0' to 145.3'. 5. Limestone from 145.3' to 158.0' Driller measured approx 12 gpm. from hole cleanout at 158.0'. WATER LEVELS One water level was taken during drilling operations. Depth 120.5' Date 9-17-84												

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hayestellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-8 Coordinates N. 25,555.0 W. 13,870.4 Drill Platform Excavation Ground Elevation 5540.6 (See * Sheet 2 of 2)

Depth and Elev. of Water Level* See notes Location approx. 85' D/S Sta. 17+00 Total Depth 81.5

*Date Measured See notes Date Begun 7-12-85 Finished 7-17-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL RIG
Sprague and Henwood 140CL Skid rig.

DRILLER
J. McLaughlin

METHOD
Bx drive from 0 to 81.5' with the following exceptions: PR's from 43.5-45.0, 53.0-54.5, 57.5-59.0, 63.0-64.5'; and rockbit from 50.0-51.5 and 69.0-81.5. Water used as drill fluid.

CASING RECORD
4-inch casing to prevent caving and water loss.

Depth	Date('85)
0-20.0	7-12
0-40.0	7-13
0-60.5	7-14
0-70.5	7-15
pulled	7-16

PROGRESS RECORD

Depth	Date('85)
0-20.0	7-12
20.0-40.0	7-13
40.0-61.5	7-14
61.5-81.5	7-15
hole	7-16 to
completion.	7-17

DRILLER'S COMMENTS
Bx drives are hard and slow going.

PIEZOMETERS
Sealed off bedrock with bentonite from 68.0 to 81.5'. Set lower porous tube piezometer (A) from 64.2 to 66.2 with silica sand pack from 63.0 to 68.0'. Sealed hole between piezometers with bentonite from 39.5 to 63.0'. Set upper porous tube piezometer (B) from 35.5 to 37.5', with

DEPTH (FT.)	CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING
0	92			
	100			
10				
	94			
	100			
20				
	100			
	100			
30				
	88			
	90			
40				
41.5	0			
	100			
	80	25	19.5	
	68			
50				
	wash			
	40			
53.5	67			
	100	26	18.6	
	100	24	10.9	
60	0			
61.5	67			
	100	30	11.1	
	100			
70				
71.0	WASH			
80				
81.5				
90				

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

GRAPHIC LOG

CLASSIFICATION AND DESCRIPTION OF MATERIAL

EMBANKMENT

0.0-41.5' GRAVEL (ZONE 2): approx. 50% fine to coarse, hard, subangular to subrounded gravel; approx. 40% fine to coarse sand; approx. 10% nonplastic fines; brown; moist to dry; moderate to weak HCl reaction. Maximum size: 3-inch. (GP-GM)

-Clay content increases (approx. 20% medium to low plasticity fines; approx. 40% fine to corase, hard gravel; approx. 40% fine to coarse sand) at following intervals:

1.8-2.5
2.8-3.0
5.2-5.6
12.2-12.3
15.5-15.8
20.1-20.3
30.1-31.0
35.3-37.5

ALLUVIUM-HOLOCENE (fan deposit)

41.4-50.0' SILTY SAND WITH GRAVEL: approx. 50% predominently fine to medium sand; approx. 30% nonplastic fines; approx. 20% fine to coarse, hard, subangular gravel. Brown; moist to dry; moderate to strong HCl reaction. Maximum size: 1-inch. (SM)

50.0-53.5' SAND AND GRAVEL: approx. 50% fine to coarse, hard, subangular to subrounded gravel; approx. 45% fine to coarse sand; approx. 5% nonplastic fines. Tan to orangish-tan; dry; moderate to strong HCl reaction. Maximum size: 2-inches. (SP-GP)

53.5-61.5' SILTY SAND WITH GRAVEL: approx. 70% fine to medium sand; approx. 15% fine, hard, subrounded gravel; approx. 15% nonplastic fines. Brown; moist; moderate to strong HCl reaction. Maximum size: 1/2-inch. (SM)

CONGLOMERATE(?) (BEAVERHEAD FORMATION) - UPPER CRETACEOUS AND LOWER TERTIARY

61.5-71.0' SILTY GRAVEL: approx. 50% fine to coarse, hard,

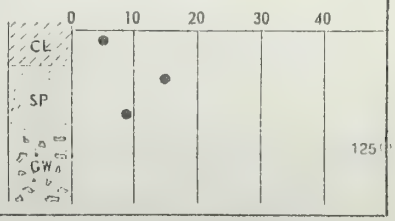
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot.

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Drill Platform Excavation

Hole No. PR- DH 85-8 Coordinates N. 25,555.0 E. W. 13,870.4 Elevation 5540.6*

Depth and Elev. of Water Level* See notes Location aprox. 85' D/S Sta. 17+00 Total Depth 81.5

*Date Measured See notes Date Begun 7-12-85 Finished 7-17-85 Logged by F. Calcagno Approved by

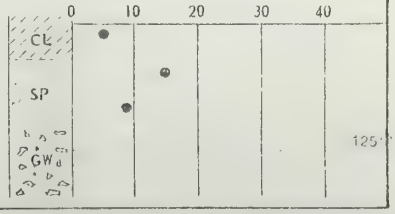
NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (0 10 20 30 40 50) Weight of Hammer 140 lb. Height of Drop 30 in.	CLASSIFICATION AND DESCRIPTION OF MATERIAL
silica sandpack from 34.5 to 39.5'. Sealed upper part of hole with bentonite from 29.0 to 34.5', dirty sand from 24.0 to 29.0' and grout from 0 to 24.0'.					10		Grout	subrounded gravel; approx. 35% fine to coarse sand; approx. 15% nonplastic fines. Tan to orange-gray; moderate to strong HCl reaction. Maximum size: 2-inches. (GM)
WATER LEVELS					20			MADISON GROUP - MISSISSIPPIAN
DURING DRILLING 37.1 7-14 45.1 7-15 45.5 7-16							Dirty Sand	71.0-81.5' LIMESTONE: Light gray; hard (H-3); oxidized.
LOWER PIEZOMETER(A) 45.5 7-17-85 47.3 7-30-85					30		Bentonite	
							Silica Sand	* Piezometer pipes were extended above this elevation after drilling and the drill platform excavation was backfilled. Piezometer A pipe was extended 7.3 feet above the platform (top of pipe at elevation 5547.9) and piezometer B pipe was extended 7.2 feet above the platform (top of pipe at elevation 5547.8). Consequently, final piezometer "depths" are 44.7 and 73.5 feet respectively for piezometers B and A.
UPPER PIEZOMETER(B) dry 7-17-85 dry 7-30-85					40		Foundation Contact	
Piezometer (B) tip at 37.5' (El. 5503.1)								
					50		Bentonite	
					60			
Piezometer (A) tip at 66.2' (El. 5474.4)							Silica Sand	
					70		Bedrock contact	
							Bentonite	
					80			
					90			

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR- DH 85-8

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-9 Coordinates N. 25,970.8 W. 14,495.8 Drill Platform Excavation Elevation 5554.9 (see* Sheet 2 of4)

Depth and Elev. of Water Level* See notes Location approx. 52' D/S Sta. 24+50 Total Depth 131.6

*Date Measured See notes Date Begun 6-1-85 Finished 6-19-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL RIG
S&H 140CL Skid rig

DRILLER
J. McLaughlin

METHOD
Took Bx drive samples with Penetration Resistance tests at approx. 2.5 foot intervals (from 22.9 to 98.1 feet). Used 2-15/16 inch rockbit at following intervals to clean hole and advance casing: 1.5-2.0; 8.0-10.0; 22.5-22.9; 24.4-25.6; 27.9-30.0; 38.0-40.0; 48.9-50.0; 82.0-82.5; 83.5-85.0; 121.5-131.6'. Water used as drill fluid.

CASING RECORD
4-inch casing to prevent caving and water loss.

Depth	Date('85)
0-20.5	6-2
0-40.0	6-3
0-60.0	6-4
0-79.5	6-5
0-85.5	6-12

(4-inch casing to 85.5' plus 3-inch casing at following depths):

Depth	Date('85)
0-92.0	6-13
0-105.3	6-14
0-120.0	6-15
0-121.0	6-16
0-110.0	6-17
0-50.0	6-18
pulled	6-19

PROGRESS RECORD

Depth	Date('85)
setup	6-1
0-31.5	6-2
31.5-54.0	6-3
54.0-77.0	6-4
77.0-79.0	6-5
travel to Billings	6-6

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
100	0			
100				
100				7.5
W				10
100				
100				
60				20
100	41	19.0		
73				
W				
74				
100	50	18.8		30
W				
40	24	11.9		
100				
31	50/.8	19.5		
100				
W				
40	16	15.4		40
84				
100	36	21.5		
60				
72	50/.8	11.7		
W				50
48				52.0
100	20	24.6		
88				
W	50/.8	14.0		
88				60
64				
70	50	13.3		
83				
90	50	12.9		
60				70
64	24	16.3		
47				74.5
100				
50	50	14.0		
100				80
100	0			
W				
100				
77				90
0				
68				
100	50/.8	5.4		
100	50/.8	4.1		
W				

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

*Large gravel following ahead of sampler from 80 to 94 feet.

0 10 20 30 40 50

CLASSIFICATION AND DESCRIPTION OF MATERIAL

EMBANKMENT

0.0-7.5' GRAVEL (ZONE2): approx. 50% fine to coarse, hard, sub-angular to subrounded gravel; approx. 40% fine to coarse sand; approx. 10% nonplastic fines; tan; dry. Moderate to strong HCl reaction. Max. size: 3±-inch. (GP-GN)

7.5-52.0' CLAYEY SAND (ZONE 1): approx. 55% fine to coarse sand; approx. 30% medium to low plasticity fines; approx. 15% fineto coarse, hard, subangular gravel; brown; moist; high dry strength. Moderate HCl reaction. Occasional thin zones of dark gray, slightly organic material, notably at 33.0 and 44.0'. Max. size: 3±-inch. (SC-SM)

52.0-74.5' CLAYEY SAND (ZONE 1): approx. 60% fine to predominantly coarse sand; approx. 30% medium to low plasticity fines; approx. 10% predominently fine to coarse, hard, subrounded gravel; brown; moist. Moderate to weak HCl reaction. Max. size: 2-inch. (SC-SM)

74.5-80.0' SAND AND GRAVEL (ZONE 1): approx. 45% fine to coarse sand; approx. 40% fine to coarse, hard subangular to subrounded gravel; approx. 15% nonplastic fines; brown; moist. Weak to no HCl reaction. Max. size: 3-inch. (SM-GM)

80.0-90.0' CLAYEY SAND (ZONE 1): approx. 50% fine to coarse sand; approx. 40% low to medium plasticity fines; approx. 10% fine, hard, subrounded gravel; mottled black and orange (oxidized); lignitic. Weak HCl reaction. Max. size: 2-inch.
-very gravelly (approx. 30% gravel) at:
82.0 to 83.5; 85.0 to 86.0 and; 88.0 to 90.0'
(SC-SM)

90.0-10.0' GRAVEL (ZONE 2): approx. 65% fine to coarse, hard sand; approx. 30% fine to coarse

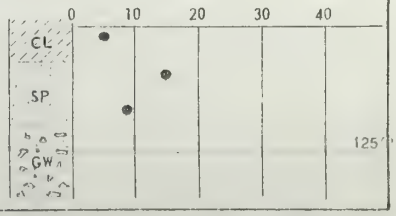
63 63 63 83 100

EXPLANATION

BLOWS/FOOT Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-9 Coordinates N. 25,970.8 W. 14,495.8 Drill Platform Excavation Ground Elevation 5554.9*

Depth and Elev. of Water Level* See notes Location approx. 52' D/S Sta. 24+50 Total Depth 131.6

*Date Measured See notes Date Begun 6-1-85 Finished 6-19-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

Depth Date('85) return to
Dillon 6-11
79.0-90.0 6-12
90.0-92.3 6-13
92.3-105.0 6-14
105.0-120.0 6-15
120.0-131.6 6-16
Piezometer and hole completion 6-17 &

DRILLER'S COMMENTS

Lots of gravel throughout hole. Had a hard time cleaning out casing as A rods are too small to get enough water through them in 4-inch casing. May have lost some sample on PR from 34.0 to 35.3 because it pulled out with difficulty. May be losing some Bx drives because we must beat back to get them out. Looks like small roots scattered in black clays in samples. Can't drive 4-inch casing further past 85.5 feet (too tight) so needed to reduce to 3-inch casing. Mike had to go to Billings on 6-13 to get more 3-inch casing. Changed oil at pump at river. Had to straighten out casing shoe to get dive barrel through it on 6-13. Couldn't take PR's below 98.1' due to gravels. Lost all water returns at 120.0'. Found wet spot on dam below rig on 6-16. Reported it to dam-tender and geologist. Wet spot turned out to be water running on surface from

CORE RECOVERY-% | BLOWS/FOOT | WATER CONTENT-% | SAMPLES FOR TESTING | DEPTH (FT.) | GRAPHIC LOG

CORE RECOVERY-%: 100, 80, 100, 88, 40, 60, 60, 80, WASH

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

DEPTH (FT.): 103.5, 110, 120, 121.5, 130, 131.6, 140, 50, 60, 70, 80, 90

CLASSIFICATION AND DESCRIPTION OF MATERIAL

hard, subrounded gravel; approx. 5% nonplastic fines; tan; moist; loose; moderate HCl reaction. Maximum size: 2-inch (GP)

ALLUVIUM-HOLOCENE

100.0-103.5' CLAYEY SAND WITH GRAVEL: approx. 60% fine to coarse, hard sand; approx. 20% low plasticity fines; approx. 20% fine subrounded to rounded, hard gravel; brown; moist; weak HCl reaction. Maximum size: 2-inch (SC-SM)

103.5-121.5' SILTY SAND WITH GRAVEL: approx. 50% fine to coarse, hard sand; approx. 40% gravel; approx. 10% nonplastic fines. Locally variable. Tan to orange-gray; weak to not cemented; strong HCl reaction. (SP-SM to SP)

MADISON GROUP - MISSISSIPPIAN

121.5-131.6' LIMESTONE: Light gray; hard (H-3); oxidized.

*Piezometer pipes were extended above this elevation after drilling and the drill platform excavation was bacfilled. Piezometer A pipe was extended 10.0 feet above the platform (top of pipe at elevation 5564.9) and piezometer B pipe was extended 10.1 feet above the platform (top of pipe at elevation 5565.0). Consequently, final piezometer "depths" are 108.0 and 127.5 feet respectively for piezometers B and A.

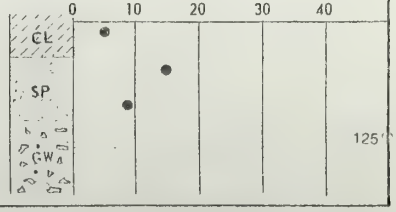
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND). 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



7-1831 (8-71)
Bureau of Reclamation

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-9 Coordinates N. 25,970.8 XX W. 14,495.8 Drill Platform Elevation XXXXX Ground Elevation 5554.9 (see * Sheet 2 of 4)

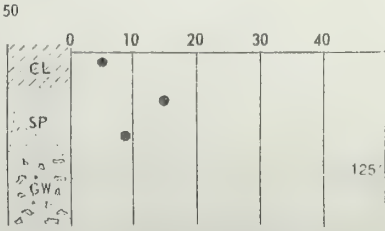
Depth and Elev. of Water Level* See notes Location approx. 52' D/S Sta. 24+50 Total Depth 131.6

*Date Measured See notes Date Begun 6-1-85 Finished 6-19-85 Logged by F. Calcagno Approved by

NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (Weight of Hammer ____ lb., Height of Drop ____ in.) 0 10 20 30 40 50	CLASSIFICATION AND DESCRIPTION OF MATERIAL
drilling. Spot dried up quickly after drilling. Read water levels in all new Clark Canyon Dam wells on 6-17. PIEZOMETERS Sealed off bedrock with bentonite from 119.5 to 131.5'. Set lower porous tube piezometer (A) from 115.5 to 117.5'; with silica sandpack from 113.0 to 119.5'. Sealed hole between piezometers with bentonite from 99.0 to 113.0'. Set upper porous tube piezometer (B) from 96.0 to 98.0', with silica sandpack from 94.0 to 95.4'. Dirty sand from 68.0 to 94.0 and bentonite from 88.0 to 20.0'. Backfilled remainder of hole with grout. Set 4-inch steel protective pipe at surface. Piezometer B (upper piezometer) has ½-inch PVC pipe approx. 0.1 feet higher than the pipe (3/4-inch PVC) for piezometer A. WATER LEVELS (During Drilling) Depth — Date('85) dry — 6-1 1.7 — 6-2 5.0 — 6-3 8.4 — 6-4 8.4 — 6-4 8.4 — 6-5 dry — 6-13 dry — 6-14 101.0 — 6-15 100.0 — 6-16 101.2 — 6-17 99.7 — 6-18			Zone 2 Zone 1 contact Zone 2 Peizometer B tip at 98.0' (El. 5456.9)		10 20 30 40 50 60 70 80 90	grout Bentonite Cement sand and fines Silica sand	

EXPLANATION

BLOWS/FOOT	Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot
CLASSIFICATION AND DESCRIPTION	Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)
PENETRATION RESISTANCE	Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE MT HOLE NO. PR- 85-9

GPO 838-002

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- DH 85-9 Coordinates N. 25,970.8 E.W. 14,495.8 Drill Platform Elevation Ground Elevation 5554.9 (see * Sheet 2 of 4)

Depth and Elev. of Water Level* see notes Location approx. 52' D/S Sta. 24+50 Total Depth 131.6

*Date Measured see notes Date Begun 6-1-85 Finished 6-19-85 Logged by F. Calcagno Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

LOWER PIEZO. (A)

Depth	Date('85)
100.9	7-17-85
101.1	7-30-85

UPPER PIEZO. (B)

Depth	Date('85)
not read	7-17-85
not read	7-30-85

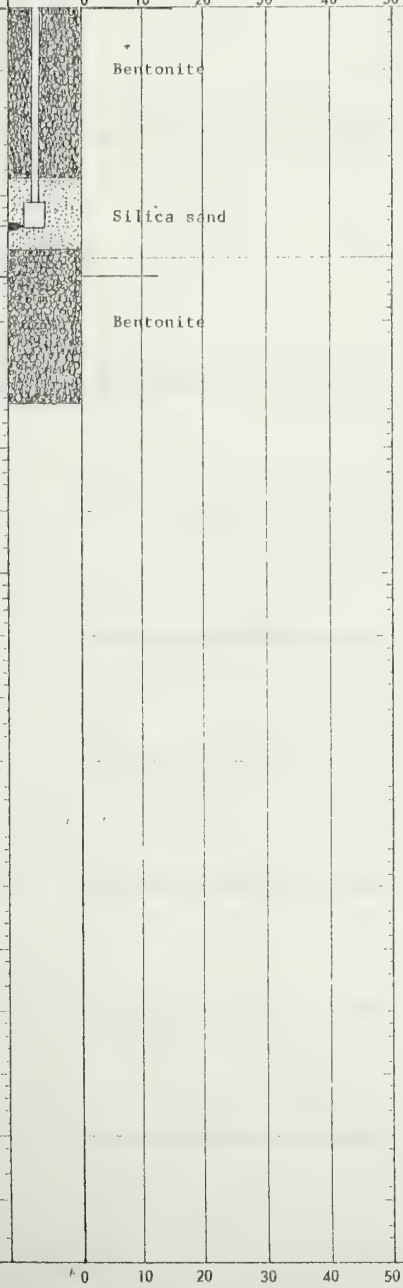
SIEVE ANALYSIS OF ZONE 2 FILTER (90.0-100.0')

Screen or Sieve size	Percent Passing
2"	100
1½"	93
1"	83
3/4"	78
½"	65
3/8"	56
No. 4	37
No. 10	27
No. 20	21
No. 40	16
No. 80	10
No. 200	6.5

CORE RECOVERY-% | BLOWS/FOOT | WATER CONTENT-% | SAMPLES FOR TESTING | DEPTH (FT.) | GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

CLASSIFICATION AND DESCRIPTION OF MATERIAL

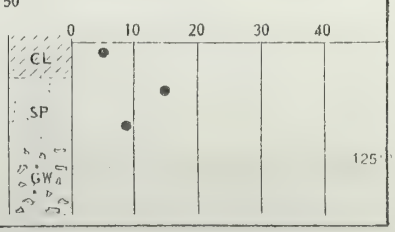


EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-10 Coordinates N. 26,196.5 E. W. 14,336.6 Ground Elevation 5470.79

Depth and Elev. of Water Level* See Notes Location approx. 330' D/S Sta. 24+50 Total Depth 20.5'

*Date Measured See Notes Date Begun 10-4-84 Finished 10-6-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
J. McLaughlin

METHOD
Drilled from 0 to 20.5' using 8x casing drive barrel and taking SPT tests at approx. 2-1/2' intervals. Casing cleaned out and cobbles penetrated with 3-7/8" rockbit. Drove 4" casing to prevent caving. Unscrewed casing shoe at 20.0' while cleaning out hole. Could not advance, so had to abandon hole. Water used as drill fluid.

CASING RECORD
Set 4" casing to prevent caving.

Depth	Date
0-12.5'	10-4-84
12.5-20.5'	10-5-84

Set 1-1/2" PVC pipe and backfilled hole after pulling casing 10-6-84.

PROGRESS RECORD

Depth	Date
0-12.5'	10-4-84
12.5-20.5'	10-5-84
Completed hole	10-6-84

PIEZOMETER
Pulled casing to start new hole. Hole stayed open to 15.0'. Set 1-1/2" PVC pipe from 0 to 15.0'. Pipe slotted from 15.0' to 10.0'. Backfilled with sand from 15.0' to 9.0'. Concreted hole from 9.0' to near top of protective pipe.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING
0	Rock		
30	45	11.3	
0	48	7.2	
53			
0			
67	90	5.2	
100			
43	65	5.4	
0			
60	92	6.9	
0	Rock		

DEPTH (FT.): 6.0, 10, 16.0, 20, 20.5, 30, 40, 50, 60, 70, 80, 90

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.
0 10 20 30 40 50

90 65 92

CLASSIFICATION AND DESCRIPTION OF MATERIAL

EMBANKMENT
0.0-6.0' Clayey Gravel with Cobbles and Boulders: Very coarse, had trouble leveling off a drill pad using a D-6 Cat. Estimate that 60% of total unit consists of flat, angular, gray limestone fragments up to 2' wide and 6" thick. Remainder of material is clayey gravel with approx. 15% low plasticity fines. (GC)

6.0-16.0' Clayey Gravel: Approx. 50% mostly subangular, hard, fine to coarse gravel; approx. 35% fine to coarse, hard sand; approx. 15% low plasticity fines; moist; crumbly; brown; strong HCl reaction. (GC)

ALLUVIUM? - HOLOCENE
16.0-20.5' Silty Gravel: Not much different from above unit except the fines appear to be nonplastic. Approx. 55% fine to coarse, hard, subangular to subrounded gravel; approx. 30% fine to coarse, hard sand; approx. 15% nonplastic fines wet; crumbly to loose; brown; a few grass roots at 16.0' with occasional roots below that depth. (GM)

Elevation of top of piezometer pipe:

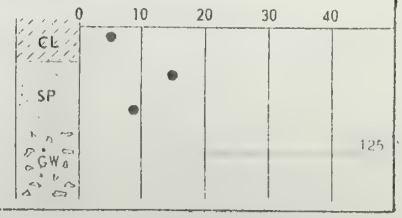
5472.7

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot.

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



7-1934 (8-71)
Bureau of Reclamation

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-10 Coordinates N. 26,196.5 XR.W. 14,336.6 Ground Elevation 5470.79

Depth and Elev. of Water Level* See Notes Location approx. 330' D/S Sta. 24+50 Total Depth 20.5'

*Date Measured See Notes Date Begun 10-4-84 Finished 10-6-84 Logged by Parish Approved by

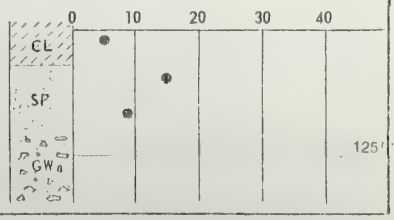
NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/ FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (Weight of Hammer ____ lb., Height of Drop ____ in.) 0 10 20 30 40 50	CLASSIFICATION AND DESCRIPTION OF MATERIAL
WATER LEVELS None taken during drilling. Depth Date					10 20 30 40 50 60 70 80 90		CONCRETE 9.0' SAND (A) 10.0'-15.0' Slotted 1-1/2" PVC 15.0'	

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- 84-10

GPO 838-902

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-10A Coordinates N. 26,193.7 E. 14,332.1 Ground Elevation 5470.92

Depth and Elev. of Water Level* See Notes Location approx. 330' D/S Sta. 24+50 Total Depth 54.0'

*Date Measured See Notes Date Begun 10-7-84 Finished 10-17-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
J. McLaughlin

METHOD
Drilled with 5-7/8" rockbit from 0 to 3.0'. Chopped and washed using Ax rods from 3.0' to 21.0'. Set 4" casing to 21.0'. Advanced hole from 21.0' to 42.8' using Bx casing drives with SPT tests at approx. 2-1/2' intervals. Chopped and washed or used rockbit to get past cobbles. Drilled from 42.8' to 54.0' using 2-15/16" rockbit. Water used as drill fluid. Casing driven as needed to prevent caving.

CASING RECORD
Set 4" casing to prevent caving. All casing pulled on completion of hole.

Depth	Date
0-21.0'	10-07-84
21.0-37.0'	10-08-84
37.0-40.5'	10-09-84
Pulled Casing	10-10-84

PROGRESS RECORD

Depth	Date
0-22.0'	10-07-84
22.0-37.0'	10-08-84
37.0-48.0'	10-09-84
48.0-54.0'	10-10-84
Completed Hole	10-17-84

PIEZOMETERS
Set porous tube piezometer (A) from 50.0' to 52.0'. Sandpacked from

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
0				6.0
				10
				16.0
0	29	*		20
67				
53	86	3.4		
92				29.0
33	66	*		30
100				
47	36	*		
				38.0
50				40
0				
100	50/0.1	12.3		42.0
0				50
				54.0
				60
				70
				80
				90

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

86
66
167

NOTE: The top 20.0' of this drill hole was not sampled. The log was prepared from observations of material from nearby hole DH 84-10.

EMBANKMENT
0.0-6.0' Clayey Gravel with Cobbles and Boulders: Very coarse, had trouble leveling off a drill site using a D-6 Cat. Estimate that 60% of total unit consists of flat, angular, gray limestone fragments up to 2' wide and 6" thick. Remainder of material is clayey gravel with approx. 15% low plasticity fines (GC).

6.0-16.0' Clayey Gravel: Approx. 50% mostly subangular, hard, fine to coarse gravel; approx. 35% fine to coarse, hard sand; approx. 15% low plasticity fines; moist; crumbly; brown; strong HCl reaction (GC).

ALLUVIUM-HOLOCENE
16.0-29.0' Silty Gravel: Not much different from above unit except the fines appear to be nonplastic. Approx. 55% fine to coarse, subangular to subrounded, hard gravel; approx. 30% fine to coarse, hard sand; approx. 15% nonplastic fines; wet; crumbly to loose; brown 16.0' to 23.0', gray 23.0' to 25.0', brown 25.0' to 29.0'. (GM)

24.0-25.0' Sandy, dark gray organic zone.

29.0-38.0' Gravel: Approx. 65% fine to coarse, subangular to subrounded, hard gravel; approx. 30% fine to coarse, hard sand; approx. 5% nonplastic fines; wet; loose; brown. (GP)

38.0-42.0' Silty Gravel: Approx. 55% fine to coarse, subangular to subrounded, hard gravel; approx. 30% fine to coarse, hard sand; approx. 15% nonplastic fines; wet; brown; crumbly. (GM)

MADISON GROUP - MISSISSIPPIAN
42.0-54.0' Limestone: Highly weathered to soft red clay

CLASSIFICATION AND DESCRIPTION OF MATERIAL

0 10 20 30 40 50

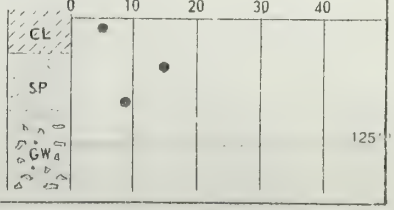
* No reliable moisture test.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- 84-10A

GPO 838-902

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-10A Coordinates N. 26,193.7 XXXX W. 14,332.1 Ground Elevation 5470.92

Depth and Elev. of Water Level* See Notes Location approx. 330' D/S Sta. 24+50 Total Depth 54.0'

*Date Measured See Notes Date Begun 10-7-84 Finished 10-17-84 Logged by Parish Approved by

NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot Weight of Hammer 140 lb. Height of Drop 30 in.	CLASSIFICATION AND DESCRIPTION OF MATERIAL
54.0' to 48.0'. Filled hole with bentonite balls from 48.0' to 38.0'. Set porous tube piezometer (B) from 34.0' to 36.0'. Sandpacked from 38.0' to 30.3' Filled hole with beutonite balls from 30.3' to 25.0'. Filled hole with concrete from 25.0' to near top of 4" steel protective pipe set approx. 1.9' above ground surface. WATER LEVELS Depth Date					0 10 20 25.0 30.3 38.0 40 48.0 50 54.0 60 70 80 90		0 10 20 30 40 50 STEEL PROTECTIVE PIPE CONCRETE BENTONITE SAND (B) 34.0'-36.0' BENTONITE (A) 50.0'-52.0' SAND	42.0' to 42.5'. Hard and medium gray rock below 42.5'. Elevations of top of piezometer pipes: A: 5472.7 B: 5472.8

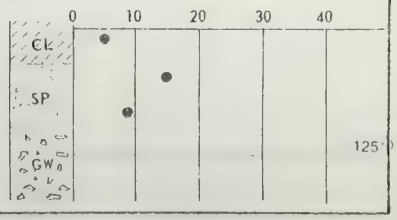
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- 84-10A

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature: Clark Canyon Dam Project: East Bench Unit State: Montana

Hole No. PR- 84-11 Coordinates N. 26,350.1 E W. 14,228.2 Ground Elevation 5455.31

Depth and Elev. of Water Level*: See Notes Location: approx. 500' D/S Sta. 24+50 Total Depth: 47.0'

*Date Measured: See Notes Date Begun: 8-28-84 Finished: 9-26-84 Logged by: Parish Approved by:

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
J. McLaughlin

METHOD
Drilled 0 to 30.0' taking Bx drive samples where possible and either 3-7/8" rockbit or Ax chop and wash where the material was gravelly. SPT tests taken at approx. 2.5' intervals where possible. 4" casing advanced during drilling to prevent caving. Water used as drill fluid. At 30.0' had trouble getting gravel out of hole and became worried about possible head in limestone. Grouted hole shut and set 10' of 4" casing in top of hole after pulling remainder of casing. Drilled out grout with 3-7/8" rockbit from 0 to 20.0'. Chopped and washed with Ax rods and drilled with 2-15/16" rockbit from 20.0 to 39.4', taking SPT tests at approx. 2.5' intervals where possible. Water used as drill fluid and Nw casing advanced during drilling to prevent caving. Drilled Nx core from 39.4 to 47.0'.

CASING RECORD
Set both 4" and Nw casing to prevent caving.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
100				
0	42	9.9		
80				
0	7	*		5.0
0				
0				10
80	32	*		11.0
0	31	*		
67				
0	39	*		
47				
100				
0				20
20	64	*		
100	100	*		
20				
0	32	*		
40				
100				
27	28	*		
70				30
0				
47				
0	40	*		36.0
0				
100				40
100				
88				
58				
				47.0
				50
				60
				70
				80
				90

GRAPHIC LOG

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

64
100

CLASSIFICATION AND DESCRIPTION OF MATERIAL

NOTE: Hole had very poor recovery. Logged primarily from Driller's Log and a few drive samples.

FILL/ALLUVIUM - HOLOCENE
0.0-5.0' Clayey Gravel: Approx. 50% fine to coarse, hard, mostly angular, gray limestone gravel; approx. 35% fine to coarse, hard, gray limestone sand; approx. 15% low plasticity fines; gray; crumbly to loose; strong HCl reaction; moist to saturated. (GC)

5.0-11.0' Silty Sand: Approx. 35 predominantly fine to medium sand; approx. 15% nonplastic fines; organic; gray to nearly black; saturated; very soft; strong HCl reaction. (SM)

11.0-36.0' Clayey Gravel: Approx. 60% fine to coarse, hard, sub-angular to subrounded gravel; approx. 25% fine to coarse, hard sand; approx. 15% low plasticity fines; brown; saturated; loose to crumbly; strong HCl reaction. (GC)

NOTE: Twisted metal shavings similar to those from a lathe were recovered from the SPT drive between 20.0' and 21.5'. They are tarnished, but not rusty, so must be made of stainless steel or some alloy.

MADISON GROUP-MISSISSIPPIAN
36.0-47.0' Limestone: Hard; medium gray; severely fractured with numerous white to rusty yellow clay-filled cracks.

Elevation of top of piezometer pipe:

5456.5

0 10 20 30 40 50

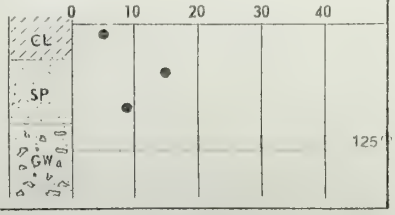
* No reliable moisture test.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- 84-11

GPO 838-002

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-11 Coordinates N. 26,350.1 E. W. 14,228.2 Ground Elevation 5455.31

Depth and Elev. of Water Level* See Notes Location approx. 500' D/S Sta. 24+50 Total Depth 47.0'

*Date Measured See Notes Date Begun 8-28-84 Finished 9-26-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

4" Casing

Depth	Date
0-14.3'	8-28-84
14.3-19.0'	8-29-84
19.0-30.0'	9-08-84

Pulled 4" casing 9-10-84. Grouted in 4" casing from 0 to 10'.

Nw Casing

Depth	Date
0-10.0'	9-12-84
10.0-31.4'	9-23-84
31.4-37.0'	9-24-84

Pulled Nw casing. 9-26-84

PROGRESS RECORD

Depth	Date
0-14.0'	8-28-84
14.0-22.0'	8-29-84
22.0-31.0'	9-08-84

Grouted hole and set 10' of 4" casing.

0-20.0'	9-12-84
20.0-32.0'	9-23-84
32.0-39.4'	9-24-84
39.4-47.0'	9-25-84

Completed Hole 9-26-84

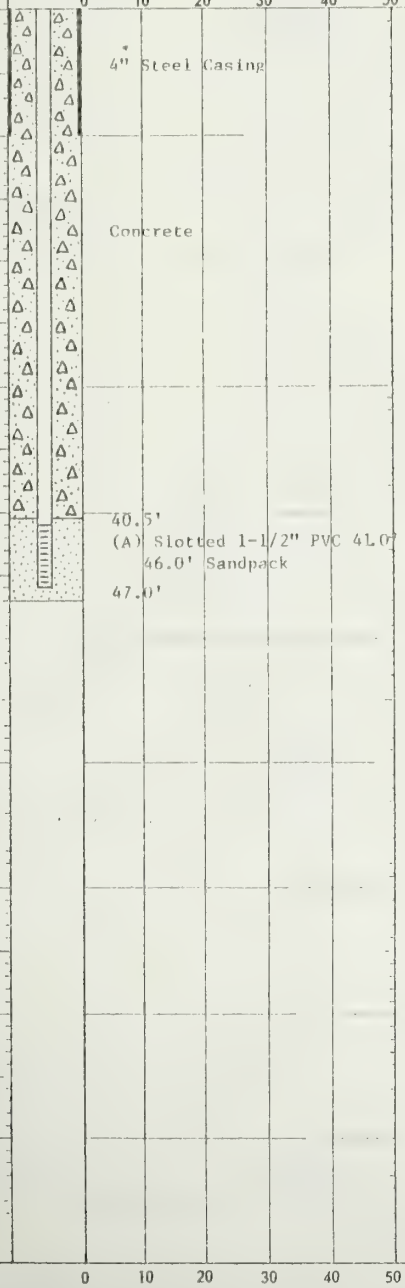
PIEZOMETER
Set 1-1/2" I.D. PVC from 0 to 46.0'. Pipe slotted from 46.0 to 41.0'. Hole sandpacked from 47.0 to 40.5'. Hole concreted from 40.5 to near top of 4" casing.

WATER LEVELS
Taken during drilling operation and may not be stable.

Depth	Date
2.0'	8-29-84
2.2'	9-08-84
4.5'	9-24-84

CORE RECOVERY-% | BLOWS/FOOT | WATER CONTENT-% | SAMPLES FOR TESTING | DEPTH (FT.) | GRAPHIC LOG

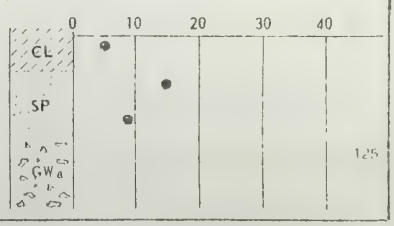
PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer _____ lb.
Height of Drop _____ in.



CLASSIFICATION AND DESCRIPTION OF MATERIAL

EXPLANATION

BLOWS/FOOT	Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot
CLASSIFICATION AND DESCRIPTION	Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)
PENETRATION RESISTANCE	Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR84-11

GPO 838-062

7-1337 (9-69)
Bureau of Reclamation

GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 1

FEATURE: Clark Canyon Dam — PROJECT: East Bench Unit — STATE: Montana

HOLE NO.: DH 85-11A — LOCATION: approx. 520' D/S Sta. 24+50 — COORDS. N. 24,345.2 E.W. 14,230.5 — GROUND ELEV.: 5455.8 — DIP (ANGLE FROM HORIZ.): 90°

BEGUN: 10-2-84 — FINISHED: 5-30-85 — DEPTH OF OVERBURDEN: - — TOTAL DEPTH: 10.4' — BEARING: -

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See notes below — LOGGED BY: F. Calcagno — LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
DRILL RIG Failing 1500 truck mounted. DRILLER J. McLaughlin METHOD 3-7/8-inch rockbit from 0 to 5.7' and piston-type Butter's Sampler from 6.1 to 7.4, 7.5 to 9.2, and 9.2 to 10.4'. Fishtailed from 7.4 to 7.5' to clean hole. NOTE: Setup on hole and drilled to 5.7' during October of 1984. During May of 1985 setup on old hole, cleaned hole and took samples. CASING RECORD Depth — Date 0-6.0' — 10-3-84 pulled — 5-30-85 PROGRESS RECORD Depth — Date setup — 10-2-84 0-5.7 — 10-3-84 5.7-10.5 — 5-30-85 hole completion — 5-30-85 HOLE COMPLETION Pulled casing and grouted hole from 0 to 10.4'. DRILLER'S COMMENTS Butter's sampler wouldn't penetrate below 10.4'. No water levels taken.	3⅞" rock bit Butters	WASH 92 100 100						5450.2 5445.4	5.6 10.4			FILL 0.0-5.6' CLAYEY GRAVEL: approx. 50% fine to coarse, hard, subangular gravel; approx. 35% fine to coarse, hard sand; approx. 15% low plasticity fines; gray to dark gray; moist; moderate to strong HCl reaction. (GC) 5.6-10.4' SILTY SAND: approx. 85% predominantly fine to medium sand; approx. 15% nonplastic fines; organic; gray to dark gray; moist; soft; moderate to strong HCl reaction.. (SM) Took three piston-type Butter's samples from 6.1 to 7.4, 7.5 to 9.2, and 9.2 to 10.4'. Moisture contents in percentage are as follows: 7.3-7.4': 51.9% 9.1-9.2': 36.6% 10.3-10.4': 43.7%

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69) Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Clark Canyon Dam | PROJECT: East Bench Unit | STATE: Montana

HOLE NO.: DH 84-12 | LOCATION: approx. 8' U/S Sta. 17+00 | GROUND ELEV.: 5579.62 | DIP (ANGLE FROM HORIZ.): Vertical

COORDS. N. 25,491.3 E.W. 13,935.5

BEGUN: 9-21-84 | FINISHED: 9-25-84 | DEPTH OF OVERBURDEN: | TOTAL DEPTH: 119.5' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: Parish | LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Co, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
DRILL Portadrill DRILLER Larry Thomas METHOD Drilled 0 to 119.5' using 7-7/8" rock-bit with air to remove cuttings. Drove 8" I.D. casing and drilled inside casing except in bedrock. Drilled "open hole" after driving casing into top of bed-rock. Took 5" thinwall push tube samples at selected intervals. Set porous tube piezometers in selected zones. CASING RECORD Used 8" I.D. casing to prevent caving and help alleviate fracturing within the embankment. All casing was pulled during installation of piezometers Depth Date 0-66.1' 9-21-84 66.1-109.0'± 9-22-84 PROGRESS RECORD Depth Date 0-68.1' 9-21-84 68.1-119.5' 9-22-84 Set piezometers and manhole cover 9-24 and 9-25-84. PIEZOMETERS Set piezometer (A) at 118.4'. Note: While pulling rods from hole, the bottom 5' rod and the 7-7/8" rockbit unscrewed and were left at the bottom	10 3/4"	0 100 0 100 0 100 0 100 0				MANHOLE COVER CONCRETE 3.0' SAND DRAIN 8.0' CONCRETE 40.4' BENTONITE 46.0' (D) 48.0-50.0' SAND 53.4' BENTONITE 70.5' (C) 72.2-74.2' SAND 78.0' BENTONITE 85.3' SAND (B) 90.7-92.7' 94.1' BENTONITE		5579.3 5570.6 5514.6 5509.8 5492.1 5486.2	0.3 9.0 65.0 69.8 87.5 93.4			NOTE: Material logged from rockbit cuttings and the trimmings of 5" thin wall push tubes. EMBANKMENT 0.0-0.3' Asphalt: Black, crumbly. 0.3-9.0' Gravely Sand: Approx. 55% fine to coarse, hard sand; approx. 35% subangular to subrounded, hard, fine to coarse gravel; approx. 10% non plastic fines; loose; moist; brown. (SP-SM) 9.0-65.0' Clayey Sand: Approx. 60 fine to coarse, hard sand; approx. 15% fine to coarse, hard, subangular to subrounded gravel; scattered small cobbles; approx. 25% low plasticity fines; moist; compact; brown. (SC) ALLUVIUM/CONGLOMERATE - HOLOCENE and UPPER CRETACEOUS TO LOWER TERTIARY* 65.0-69.8' Silty Sand: Approx. 85% fine sand; approx. 15% nonplastic fines; saturated; runny; brown. (SM) 69.8-87.5' Silty Sand: Approx. 55% fine to coarse, hard sand; approx. 25% fine to coarse, hard, subangular to subrounded gravel; approx. 20% very low plasticity fines; moist; brown. (SM-SC) 87.5-93.4' Sand: Approx. 90% fine sand; approx. 10% nonplastic fines; saturated; soft to runny; brown. (SP-SM) 93.4-100.5' Silty Sand: Approx. 60% fine to coarse, hard sand; approx. 20% fine to coarse, hard, subangular to subrounded gravel; approx. 20% non-plastic fines; wet; brown. (SM) 100.5-106.7' Gravel: Approx. 70% fine to coarse, hard, subangular to sub-rounded gravel; approx. 25% fine to coarse, hard sand; approx. 5% non-plastic fines; loose; saturated; contains many red quartzite fragments. (GP) MADISON GROUP-MISSISSIPPIAN 106.7-119.5' Limestone: Slightly weathered and reddish near top, grading to medium gray at depth. Apparently severely fractured, because up to " diameter angular fragments were being blown from the hole while cleaning it out at 119.5'. Heavist water producer of any of the zones encountered in the Portadrill holes. Driller measured about 45 gpm discharge while blowing out the hole at 119.5'. The water

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hayestellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

*Alluvial contact probably lies at approx. 82.0'. (Embankment material from 65.0 to 82.0'± was wet to saturated and appeared significantly different from overlying embankment in the field.) Conglomerate contact assumed at 100.5'.

7-1337 (9-69) Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 3

FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana

HOLE NO. DH 84-12 LOCATION approx. 8' U/S Sta. 17+00 GROUND ELEV. 5579.62 DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 9-21-84 FINISHED 9-25-84 DEPTH OF OVERBURDEN TOTAL DEPTH 119.5' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY Parish LOG REVIEWED BY

COORDS. N 25,491.3 E. W. 13,935.5

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
of the hole. The lower sandpack was extended to completely encase them and piezometer (A). The sandpack fills the hole from 119.5' to 112.2'. Hole filled with bentonite balls from 112.2' to 94.1'. Set piezometer (B) at 93.7'. Sandpacked hole from 94.1' to 85.3'. Filled hole with bentonite balls from 85.3' to 78.0'. Set piezometer (C) at 74.2'. Sandpacked hole from 78.0' to 70.5'. Filled hole with bentonite balls from 70.5' to 53.4'. Set piezometer (D) at 50.0'. Sandpacked hole from 53.4' to 46.0'. Filled hole with bentonite balls from 46.0' to 40.4'. Filled hole with concrete from 40.4' to 8.0'. Set drain sleeves around piezometer pipes and filled sand from 8.0' to 3.0'. Filled hole with concrete from 3.0' to 0' and set manhole cover over the piezometer pipes. SAMPLING 5" diameter thinwall samples were completed at depths of 66.1' to 68.1', 68.9' to 70.45', and 89.3' to 92.07'. Attempts were made to push tubes at 30.5', 60.5', and 80.5'. Where sufficient material was retined in the	10 3/4"	D				BENTONITE 112.2' SAND (A) 116.4- 119.5'		5479.1 5472.9 5460.1	100.5 106.7 118.4' 119.5'			quantity increased with depth in the limestone. Elevations of top of piezometer pipes: A: 5579.0 B: 5579.1 C: 5579.1 D: 5579.2

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation

GPO 894-401

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Clark Canyon Dam — PROJECT: East Bench Unit — STATE: Montana

HOLE NO.: DH 84-12 — LOCATION: approx. 8' U/S Sta. 17+00

COORDS. N. 25,491.3 W. 13,935.9 — GROUND ELEV.: 5579.62 — DIP (ANGLE FROM HORIZ.): Vertical

BEGUN: 9-21-84 — FINISHED: 9-25-84 — DEPTH OF OVERBURDEN: — TOTAL DEPTH: 119.5' — BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: Parish — LOG REVIEWED BY:

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
push tubes, sack samples were collected. PRIMARY WATER PRODUCING ZONES NOTED DURING DRILLING 1. Silty Sand from 65.0' to 69.8'. 2. Sand from 87.5' to 93.4'. 3. Gravel from 100.5' to 106.7'. Driller measured approx. 15 gpm from hole cleanout. 4. Limestone from 106.7' to 119.5' By far the most water encountered in any of the Portadrill holes. Driller measured approx. 45 gpm from hole cleanout at 119.5'. WATER LEVELS One water level was taken during drilling operations. The casing was set into the top of the limestone at the time. Depth 71.3 — Date 9-24-84									10 20 30 40 50 60 70 80 90			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoyatellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR-84-13 Coordinates N. 25,730± Rx W. 13,690± Ground Elevation 5505±

Depth and Elev. of Water Level* See Notes Location approx. 325' D/S Sta. 16+50 Total Depth 13.4'

*Date Measured See Notes Date Begun 10-30-84 Finished 11-2-84 Logged by Parish Approved by

NOTES
Water losses, type and size of hole, drilling method and conditions, Caving and other information

DRILL
Failing 1500 truck-mounted.

DRILLER
J. McLaughlin

METHOD
Set up and blocked rig for Butter's sampling. Drilled with 3-7/8" rockbit to 1.57'. Took Butter's sample from 1.57' to 3.36'. Piston slipped and pushed part of sample out of tube. Decided to quit Butter's sampling until warmer weather. Drilled with 3-7/8" rockbit from 3.36' to 5.5'. Tried SPT at 5.5', but on a rock. Drilled from 5.5' to 6.0' with 3-7/8" rockbit. Took SPT from 6.0' to 7.5'. Drilled with 3-7/8" rockbit from 7.5' to 9.3'. Took SPT from 9.3' to 10.8'. Drilled with 3-7/8" rockbit from 10.8' to 13.4'. Water and Revert used as drill fluid.

CASING RECORD
None used.

PROGRESS RECORD
Set up for Butter's sampling 10-30 and 10-31-84. Drilled from 0 to 3.36' and took Butter's sample on 11-1-84. Drilled from 3.36' to 13.4' and set piezometer on 11-2-84.

PIEZOMETER
Set 3/4" PVC pipe to 12.5'. Slotted from 12.5' to 7.5'. Sand-packed hole from 12.5' to 6.5'.

CORE RECOVERY-%	BLOWS/FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)
0				
62				
0				5.5
53	32*	14.1		
0				9.3
13	41	**		10
				13.4

*Probably neither S.P.T. nor good. Poor recovery indicates they were on rocks.

PENETRATION RESISTANCE
Blows per Foot
Weight of Hammer 140 lb.
Height of Drop 30 in.

0 10 20 30 40 50

GRAPHIC LOG

CLASSIFICATION AND DESCRIPTION OF MATERIAL

NOTE: Hole logged from driller's reports.

ALLUVIUM? - HOLOCENE (fan deposit)
0.0-5.5' Silty Sand: Approx. 60 fine sand; approx. 40% nonplastic fines; moist; firm; brown. (SM)

5.5-9.3' Silty Sand with Gravel: Approx. 60% predominantly fine sand; approx. 10% fine to coarse, hard gravel; occasional cobbles to 5"±; approx. 30% nonplastic fines; moist; firm; brown. (SM)

CONGLOMERATE? (BEAVERHEAD FORMATION)
UPPER CRETACEOUS AND LOWER TERTIARY
9.3-13.4' Silty Gravel: Approx. 50% fine to coarse, hard, subangular to subrounded gravel; approx. 35% fine to coarse, hard sand; approx. 15% nonplastic fines; moist; loose; brown. (GM)

0 10 20 30 40 50

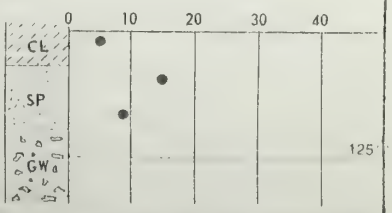
** No reliable moisture test.

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND. 95% predominantly medium sand, 5% nonplastic fines. max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



SUBSURFACE EXPLORATION - PENETRATION RESISTANCE AND LOG

Feature Clark Canyon Dam Project East Bench Unit State Montana

Hole No. PR- 84-13 Coordinates N. 25,730+ E. 13,690+ Ground Elevation 5505+

Depth and Elev. of Water Level* See Notes Location approx. 325' D/S Sta. 16+50 Total Depth 13.4'

*Date Measured See Notes Date Begun 10-30-84 Finished 11-2-84 Logged by Parish Approved by

NOTES Water losses, type and size of hole, drilling method and conditions, Caving and other information	CORE RECOVERY-%	BLOWS/ FOOT	WATER CONTENT-%	SAMPLES FOR TESTING	DEPTH (FT.)	GRAPHIC LOG	PENETRATION RESISTANCE Blows per Foot (0 10 20 30 40 50) Weight of Hammer 140 lb. Height of Drop 30 in.	CLASSIFICATION AND DESCRIPTION OF MATERIAL
(Hole caved shut below 12.5'.) Filled hole with bentonite balls from 6.5' to surface. WATER LEVELS Depth Date					6.5		BENTONITE	
					10		SAND	
					12.5			
					20			
					30			
					40			
					50			
					60			
					70			
					80			
					90			

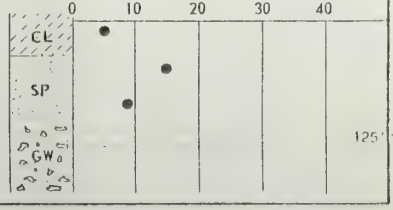
0 10 20 30 40 50

EXPLANATION

BLOWS/FOOT — Record number of blows required for one foot of penetration. If 50 blows result in less than one foot of penetration, record depth penetrated; thus, 50/.4 indicates 0.4 foot penetrated with 50 blows, extrapolated as 125 blows/foot

CLASSIFICATION AND DESCRIPTION — Describe soil type, with emphasis on inplace condition. Include Unified Soil Classification symbol. EXAMPLE: POORLY GRADED SAND, 95% predominantly medium sand, 5% nonplastic fines, max size 1/4 inch, firm, moist, gray, uncemented (SP)

PENETRATION RESISTANCE — Plot, as shown at right. Actual values ●, extrapolated values at 50, open circle with extrapolated value 125○



FEATURE Clark Canyon Dam PROJECT East Bench Unit STATE Montana HOLE NO. PR- 84-13

CLARK CANYON DAM - RIGHT ABUT. OBSERVATION WELLS IN SEEP TABLE 1 SHEET 1 OF 2

HOLE	LOCATION	TOP PIPE ELEV.	GROUND ELEV.	BOT. HOLE ELEV.	HOLE TYPE	DATE COMPLETED	REMARKS
OW84-201	N.25,684 W.13,704	5506.9	5503.1	5483.3	2" DIA. X 3' LONG WELL POINT (NO. 8 SCREEN) WITH 20.6' OF 1½" GALVANIZED RIZER PIPE. 3.8' STICKUP	7/26/84	GRAVEL BLANKET 0-3'; ALLUVIAL FAN 3-19.4'. DRIVE WELL POINT BY HAND
OW84-202	N.25,543 W.13,759	5523.4	5521.1	5507.1	15.2' OF BxCs. 1.9' STICKUP. 0.7' OPEN HOLE BELOW BxCs	8/1/84	GRAVEL BLANKET 0-3'; ALLUVIAL FAN 3-14'. PUSHED BxCs TO 13.3' WITH DRILL RIG. CHOPPED HOLE TO 14'. HOLE 13.3-14' SLOUGHING. LOST 20 GPM H_2O AT BOTTOM OF HOLE.
OW84-203	N.25,664 W.13,711	5511.2	5503.9	5500.6	10.2' OF BxCs. 1.3' STICKUP. 0.4' OPEN HOLE BELOW BxCs	8/1/84	LIMESTONE GRAVEL (FILL) 0-1; ALLUVIAL FAN 1-8.8'; TERTIARY CONGLOMERATE (?) 8.8-9.3'. HAMMERED BxCs WITH DRILL RIG 0-1 AND 8.8-8.9'; PUSHED BxCs WITH DRILL RIG 1-8.8'. CHOPPED HOLE 8.9-9.3'. UNABLE TO PENETRATE DEEPER WITH CHOP RODS. LOST 30 GPM H_2O AT BOTTOM OF HOLE
OW84-204	N.25,766 W.13,615	5507.7	5507.3	5489.4	15.0' OF BxCs. 0.4' STICKUP. 3.3' OPEN HOLE BELOW BxCs	8/2/84	ALLUVIAL FAN 0-17.9'. PUSHED BxCs TO 14.6' WITH DRILL RIG. CHOPPED HOLE 14.6-17.9'. UNABLE TO PENETRATE DEEPER WITH CHOP RODS BECAUSE OF SLOUGHING. LOST 5-10 GPM H_2O AT BOTTOM OF HOLE.
OW84-205	N.25,870 W.13,566	5604.8	5504.6	5489.5	15.0' OF BxCs. 0.2' STICKUP. 0.3' OPEN HOLE BELOW BxCs	8/2/84	ALLUVIAL FAN. 0-15.1'. PUSHED BxCs TO 14.8' WITH DRILL RIG. CHOPPED HOLE 14.8 TO 15.1'. UNABLE TO PENETRATE DEEPER WITH CHOP RODS BECAUSE OF SLOUGHING. LOST 10 GPM H_2O AT BOTTOM OF HOLE.
OW84-206	N.25,998 W.13,552	5492.9	5492.0	5477.5	15.0' OF BxCs. 0.1' STICKUP. 0.4' OPEN HOLE BELOW BxCs	8/2/84	ALLUVIAL FAN 0-13.5'. TERTIARY CONGLOMERATE (?) 13.5-15.3'. HAMMERED BxCs TO 14.9' USING DRILL RIG (COULD HAVE PUSHED TO 13.5'). CHOPPED HOLE 13.5 TO 15.3 WITH CHOP RODS. UNABLE TO PENETRATE DEEPER BECAUSE OF FIRMNESS AND GROUTING IN RODS. LOST 10 GPM H_2O AT BOTTOM OF HOLE.
OW84-207	N.26,039 W.13,576	5490.2	5486.7	5475.2	14.0' OF BxCs. 3.5' STICKUP. 0.7' OPEN HOLE BELOW BxCs	8/2/84	ALLUVIAL FAN 0-7.0'; TERTIARY CONGLOMERATE (?) 7.0-10.7'. PUSHED BxCs 0-7.0' WITH DRILL. HAMMERED BxCs 7.0-10.5'; CHOPPED HOLE 10.5-10.9' WITH CHOP RODS. UNABLE TO PENETRATE DEEPER BECAUSE OF FIRMNESS AND CUTTINGS GROUTING IN WASH RODS.
OW84-208	N.26,018 W.13,811	5484.3	5484.0	5474.0	10.0' OF BxCs. 0.3' STICKUP. 0.3' OPEN HOLE BELOW BxCs	8/2/84	ALLUVIAL FAN 0-6.0'; TERTIARY CONGLOMERATE (?) 6.0-10.0'. PUSHED BxCs 0-6.0' WITH DRILL RIG. HAMMERED BxCs 6.0-9.7' WITH DRILL RIG. CHOPPED HOLE 9.7-10.0' WITH CHOP RODS. UNABLE TO PENETRATE DEEPER BECAUSE OF MATERIAL FIRMNESS AND CUTTINGS GROUTING IN WASH RODS.

47 0860

HOLE	LOCATION	TOP PIPE ELEV.	GROUND ELEV.	BOT. HOLE ELEV.	HOLE TYPE	DATE COMPLETED	REMARKS
OW84-208	N.25,624 W.13,964	5490.7	5484.6	5475.3	14.8' OF BxCs. 6.1' STICKUP. 0.6' OPEN HOLE BELOW BxCs.	8/1/84	GRAVEL BLANKET 0-3'±; ALLUVIAL FAN 3.0-6.0'; TERTIARY CONGLOMERATE 6.0 TO 9.3'. PUSHED BxCs 0-6.0' WITH DRILL RIG; HAMMERED BxCs 6.0-8.7' WITH DRILL RIG; CHOPPED HOLE 8.7-9.3' WITH CHOP RODS. UNABLE TO PENETRATE BECAUSE OF MATERIAL FIRMNESS AND CUTTINGS GROUTING IN WASH RODS
OW84-210	N.25,759 W.13,855	5497.6	5493.7	5477.5	15.2' OF BxCs. 3.9' STICKUP 4.9' OF OPEN HOLE BELOW BxCs	8/1/84	GRAVEL BLANKET 0-3'±; ALLUVIAL FAN 3.0-10.5'; TERTIARY CONGLOMERATE (?) 10.5-16.2'. PUSHED BxCs 0-10.5' WITH DRILL RIG. HAMMERED BxCs 10.5-11.3'; CHOPPED HOLE 11.3-16.2' WITH CHOP RODS. UNABLE TO PENETRATE DEEPER BECAUSE OF MATERIAL FIRMNESS AND CUTTINGS GROUTING IN WASH RODS.
OW84-211	N.25,753 W.13,738	5502.1	5498.1	5429.6	1¼"DIA. x 3'LONG WELL POINT (No. 6 SCREEN) WITH 9.5' OF 1¼" GALVANIZED RISER PIPE	8/9/84	DRIVE WELL POINT BY HAND. UNABLE TO DETERMINE MATERIAL CHANGE, HOWEVER, WELL POINT INCREASINGLY DIFFICULT TO DRIVE WITH DEPTH. UNABLE TO DRIVE DEEPER.
OW84-212	N.25,848 W.13,652	5502.3	5497.5	5485.8	1¼"DIA. x 3'LONG WELL POINT (No. 6 SCREEN) WITH 13.5' OF 1¼" GALVANIZED RISER PIPE	8/9/84	SAME AS OW84-211
OW84-213	N.25,950 W.13,622	5496.5	5491.5	5479.1	1¼"DIA. x 3'LONG WELL POINT (No. 6 SCREEN) WITH 14.4' OF 1¼" GALVANIZED RISER PIPE	8/9/84	SAME AS OW84-211
OW84-214	N.25,871 W.13,748	5493.7	5490.1	5474.2	1¼"DIA. x 3'LONG WELL POINT (No. 6 SCREEN) WITH 12.5' OF 1¼" GALVANIZED RISER PIPE	8/9/84	SAME AS OW84-211
OW84-215	N.25,878 W.13,851	5490.4	5487.3	5472.2	1¼"DIA. x 3'LONG WELL POINT (No. 6 SCREEN) WITH 15.2' OF 1¼" GALVANIZED RISER PIPE	8/9/84	SAME AS OW84-211

NOTES:

1. ALLUVIAL FAN - RELATIVELY SOFT MATERIAL (SILT AND SAND WITH CLAY AND GRAVEL) WHERE BxCs COULD BE ADVANCED BY PUSHING WITH THE DRILL RIG.

2. TERTIARY CONGLOMERATE(?)-UNDERLIES ALLUVIAL FAN DEPOSITS. IS A SILTY, COMPACT, POSSIBLY SLIGHTLY CEMENTED CONGLOMERATE. BxCs HAD TO BE ADVANCED USING THE DRILL RIG AND HAMMERS. IMPOSSIBLE TO PUSH BxCs WITH RIG. MAY BE IN PART LATER TERTIARY TERRACE GRAVEL.

3. OW84-201 THROUGH-203, 206, -210 AND -213 DESTROYED IN LATE 1984 WHEN SEEPAGE AREA DRAINS WERE INSTALLED

47 0860

TABLE 2

CLARK CANYON DAM DRILLHOLE AND INSTRUMENTATION DATA

HOLE	LOCATION	TOP PIPE ELEV.	BOTTOM PIPE ELEV.	GROUND ELEV.	HOLE TYPE	DATE COMPLETED
PR-84-1	N. 25,620.2 W. 13,301.8	- DESTROYED -	——	5503.1	PENETRATION RESISTANCE W/ PIEZOS.	5/15/84
DH-84-2 piezo. A B C	N. 25,607.1 W. 14,095.5	5579.4 5579.5 5579.6	5482.7 5488.9 5508.9	5579.2	10 3/4" Portadrill hole w/ PIEZOS. and thin wall push.	9/10/84
PR-85-3 piezo. A B	N. 25,651.4 W. 13,781.9	5514.4 5514.5	5463.3 5478.2	5510.2	PENETRATION RESISTANCE W/ PIEZOS.	5/19/85
DH 85-3A	N. 25,646.3 W. 13,783.2	——	——	5507.8	Butters thin wall drill hole	5/29/85
PR-85-3B	N. 25,632.6 W. 13,775.8	——	——	5510.3	Butters thin wall w/PENET. RESIST.	7/26/85
PR-85-4 piezo. A B	N. 25,603.6 W. 14,039.2	5554.0 5554.1	5470.0 5434.5	5546.5 (later raised to conform to slope of dam face)	PENETRATION RESISTANCE W/ PIEZOS.	7/11/85
PR-84-5 piezo. A B	N. 25,779.3 W. 13,917.8	5504.5 5504.6	5471.6 5433.4	5502.4	PENETRATION RESISTANCE W/ PIEZOS.	11/4/84
PR-84-6 piezo. A B	N. 25,954.8 W. 13,846.5	5486.6 5487.0	5457.4 5417.4	5485.4	PENETRATION RESISTANCE W/ PIEZOS.	5/17/84
DH 84-7 piezo. A B C	N. 25,931.7 W. 14,539.8	5579.3 5579.4 5579.5	5429.2 5439.4 5510.0	5579.3	10 3/4" Portadrill hole w/ PIEZOS. and thin wall push	8/20/84
PR-85-8 piezo. A B	N. 25,550.5 W. 13,870.4	5547.7 5547.8	5474.4 5503.1	5540.6 (later raised to conform to slope of dam face)	PENETRATION RESISTANCE W/ PIEZOS.	7/17/85
PR 85-9 piezo. A B	N. 25,970.8 W. 14,495.8	5564.2 5565.0	5437.2 5456.2	5554.2 (later raised to conform to slope of dam face)	PENETRATION RESISTANCE W/ PIEZOS.	6/19/85
PR-84-10 slotted pipe	N. 26,196.5 W. 15,336.3	5472.7	5455.8	5470.8	PENETRATION RESISTANCE W/ SLOTTED PIPE	8/3/84
PR-84-10A piezo. A B	N. 26,193.7 W. 14,332.1	5412.7 5412.8	5478.0 5435.7	5470.9	PENETRATION RESISTANCE W/ PIEZOS.	10/17/84
PR-84-11 slotted pipe	N. 26,350.1 W. 14,228.2	5456.5	5409.3	5455.3	PENETRATION RESISTANCE W/ SLOTTED PIPE	9/26/84

47 0703

K+E 10 X 10 TO THE INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

TABLE 2

HOLE	LOCATION	TOP PIPE ELEV.	BOTTOM PIPE ELEV.	GROUND ELEV.	HOLE TYPE	DATE COMPLETED
DH85-111A	N. 26,345.2 W. 14,230.5	———	———	5455.8	Buttress thin wall drill hole	5/30/85
DH84-12 piezo. A B C D	N. 25,491.3 W. 13,945.5	5579.0 5579.1 5579.1 5579.2	5464.2 5485.9 5505.4 5529.6	5579.6	10" ID Portair II AQUIF. WITH PIEZOS, and thin wall push	4/25/84
PR-84-14	N. 25,730 ± W. 13,690 ±	—DESTROYED—	———	5505 ±	PENETRON RESISTANCE WITH STEEL PIPE	10/30/84
DH-114	N. 26,750 W. 14,925	5650.6	5400.6	5649.6	REHABILITATED OBSERVATION WELL	rehab. on 5/22/84 (250' of ¾-in. PVC pipe)
DH-122	N. 24,632 W. 12,780	5593.8	5332.9	5592.5	REHABILITATED OBSERVATION WELL	rehab. on 5/17/84 (260.4' of ¾-in. PVC pipe)
DH-134	N. 26,447 W. 15,398	5565.5	5474.0	5564.3	REHABILITATED OBSERVATION WELL	rehab. on 5/22/84 (85.5' of ¾-in. PVC pipe)
DH-140	N. 25,950 W. 13,700	5594.0	5491.8	5590.3	REHABILITATED OBSERVATION WELL	rehab. on 5/17/84 (52.2' of ¾-in. PVC pipe)
DH-141	N. 25,562.5 W. 13,353.2	5533.0	5477.0	5530.1	REHABILITATED OBSERVATION WELL	rehab. on 5/2/84 (56.9' of ¾-in. PVC pipe)
DH-142	N. 27,000 W. 15,150	5627.2	5502.2	5625.0	OBSERVATION WELL TOP OF PIPE SURVEYED IN 1985	NO REHABILITATION (225.0' of ¾-in. steel pipe)
W-4	N. 26,257.8 W. 15,393.3	5593.0	NOT MEASURED	5591 ±	OPEN HOLE (ABANDONED WATER WELL) TOP OF CASING SURVEYED IN 1985	NO REHABILITATION

47 0703

1982 10 30 TO THE INCH 5 TO INCH
KEUFFEL & ESSER CO. MADE IN U.S.A.

7-1734 (8-70)
Bureau of Reclamation

SOILS ENGINEERING BRANCH

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS (Proctor Compaction)

PROJECT INSTRUMENTATION PROGRAM FEATURE CLARK CANYON DAM

TABLE 3
SHEET 1 OF 2

IDENTIFICATION				PARTICLE-SIZE FRACTIONS IN PERCENT						CONSISTENCY LIMITS			SPECIFIC GRAVITY				COMPACTION TEST				SUPPLEMENT TO TABLE 3, PAGE 1
				FINES										PLUS NO. 4							
MATERIAL SAMPLE NUMBER TYPE	HOLE NUMBER	DEPTH - feet (m)	CLASSIFICATION SYMBOL	SMALLER THAN 0.005 mm	0.005 TO 0.074 mm	SAND NO. 200 (0.074 mm) TO NO. 4 (4.76 mm)	GRAVEL NO. 4 (4.76 mm) TO 3 IN. (76.2 mm)	COBBLES 3 IN. (76.2 mm) TO 5 IN. (127 mm)	OVERSIZE LARGER THAN 5 IN. (127 mm)	LIQUID LIMIT - %	PLASTICITY INDEX - %	SHRINKAGE LIMIT - %	MINUS NO. 4	BULK	APPARENT	ABSORPTION - %	MAXIMUM DRY DENSITY - pcf (gm/cm³)	OPTIMUM WATER CONTENT - %	PENETRATION RESISTANCE - psi (kg/cm²)	SAMPLE TYPE	
		FEET																			
AF	PR 84-1	0-3.5'	CL-ML	16	41	43	0													C	1
1	DH 84-2	22.5-23.0	SC	←	20.0	41.0	39.0	0	0	24.0	10.0									C	2,3
1	DH 84-2	36.5-37.1	SC	←	25.0	48.0	27.0	0	0	25.0	9.0									C	4,5
1	DH 84-7	30.6-31.1	SM	←	28.0	38.0	34.0	0	0	NP	NP									C	6,7
1	DH 84-7	90.6-90.7	SC	←	38.0	36.0	26.0	0	0	33.0	18.0									C	8,9
RA	DH 84-7	120.6-121.6	SM	8.0	29.0	58.0	5.0	0	0	NP	NP									C	10,11
2	PR 85-9	90.0-100.0	GP	←	6.5	30.5	63.0	0	0											C	12,13
1	DH 84-12	30.5-30.7	GC	←	25.0	33.0	42.0	0	0	28.0	14.0									C	14,15
AF	DH 84-12	80.5-81.4	SM	13.0	17.0	49.0	21.0	0	0	NP	NP									C	16,17
1	DH 84-2	90.6-92.5	SM	←	20	50	30	0	0	VISUAL CLASSIFICATION						IN PLACE DRY DENSITY PCF	122.9	11.3	MOISTURE CONTENT %	TW	18
1	DH 84-7	60.6-62.25	SC	←	40	50	10	0	0								117.5	14.9		TW	19
RA	DH 84-7	120.6-121.6	SP/SC	←	20	60	20	0	0								123.6	14.9		TW	19
RA	DH 84-7	125.6-127.8	SC	←	25	75	TRACE	0	0								123.1	13.2		TW	19
1	DH 84-12	66.1-68.1	SM	←	15	85	TRACE	0	0								114.6	17.2		TW	20
1	DH 84-12	68.9-70.45	SM	-	-	-	-	-	-								123.2	14.6		TW	20
AF	DH 84-12	89.3-92.07	SP	-	-	100	1	-	-								107.2	21.2		TW	20
AF	DH 85-3A	5.3-6.8	SM														82.8	22.0		B	21
AF	DH 85-3A	6.8-8.3	-														95.6	21.8		B	22
AF	PR 85-3B	6.6-7.1	SM														97.2	18.3		B	24
AF	PR 85-3B	7.1-9.0	SM														93.6	15.3		B	25
AF	PR 85-3B	18.0-19.8	SM														111.3	24.0		B	26
AF	PR 85-3B	19.8-21.9	SM														105.3	18.2		B	27

TABLE 3 SHEET 1 OF 2

NOTE: Numbers in parentheses are metric equivalents of numbers directly above.

7-1734 (8-70)
Bureau of Reclamation

SOILS ENGINEERING BRANCH

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS (Proctor Compaction)

PROJECT INSTRUMENTATION PROGRAM FEATURE CLARK CANYON DAM

TABLE 3
SHEET 2 OF 2

IDENTIFICATION				PARTICLE-SIZE FRACTIONS IN PERCENT						CONSISTENCY LIMITS			SPECIFIC GRAVITY				COMPACTION TEST				
MATERIAL ~~SAMPLE NUMBER~~ TYPE	HOLE NUMBER	DEPTH - feet (m)	CLASSIFICATION SYMBOL	FINES: SMALLER THAN 0.005 mm	FINES: 0.005 TO 0.074 mm	SAND NO. 200 (0.074 mm) TO NO. 4 (4.76 mm)	GRAVEL NO. 4 (4.76 mm) TO 3 IN. (76.2 mm)	COBBLES 3 IN. (76.2 mm) TO 5 IN. (127 mm)	OVERSIZE LARGER THAN 5 IN. (127 mm)	LIQUID LIMIT - %	PLASTICITY INDEX - %	SHRINKAGE LIMIT - %	MINUS NO. 4	PLUS NO. 4: BULK	PLUS NO. 4: APPARENT	PLUS NO. 4: ABSORPTION - %	MAXIMUM DRY DENSITY - pcf (gm/cm³)	OPTIMUM WATER CONTENT - %	PENETRATION RESISTANCE - psi (kg/cm²)	SAMPLE TYPE	
		FEET																			SUPPLEMENT TABLE 3, PAGE A-
RF	DH85-11A	6.1-7.4	SM		VISUAL CLASSIFICATION										IN PLACE DRY DEN. PCF		74.4	51.9	H₂O CONTENT	B	28
RF	DH85-11A	7.5-9.2	SM			〃		〃									86.5	36.6		B	29
RF	DH85-11A	9.2-10.4	SC			〃		〃									78.7	43.7		B	30
AF	10'D/S	1.1-2.1	CL-ML	23.1	49.1	27.8	0	0	0	27.3	6.5	-	2.66	-	-	-	107.8	16.2	1100	FD	31
	PR84-13							IN PLACE DENSITY (SAND CONE) & MOISTURE →									98.1	18.1		FD	
AF	10'D/S	3.1-4.1	ML	14.6	45.5	39.9	0	0	0	23.2	2.4	-	2.67	-	-	-	112.5	13.7	-	FD	
	PR84-13							IN PLACE DENSITY (SAND CONE) & MOISTURE →									93.5	12.4		FD	45
AF	SURFACE SAMPLE		CL-ML	29	39	32	0	(COORDINATES N. 25,832; W. 13,904)												TP	46
Z	DRAIN STA. 9+70		GP	←	4	29	67													TP	47
S	DRAIN STA. 9+70		SP	←	5	90	5													TP	48
G	DRAIN STA. 9+70		GP		1	2	97													TP	49
AF	DRAIN STA. 9+70		GP	2	5	16	77													TP	50

TABLE 3 SHEET 2 OF 2

EXPLANATION

MATERIAL TYPE
- 〃 〃 AF = ALLUVIAL FAN
- 〃 〃 RA = RIVER ALLUVIUM
- 〃 〃 RF = RAILROAD FILL
- 〃 〃 S = SAND AROUND ORIGINAL TOE DRAIN
- 〃 〃 G = GRAVEL AROUND ORIGINAL TOE DRAIN
- 〃 〃 1 = ZONE 1 EMBANKMENT
- 〃 〃 2 = ZONE 2 EMBANKMENT

SAMPLE TYPE
- C = CORE (DISTURBED)
- 〃 〃 TW = 5" DIA. UNDISTURBED THIN WALL
- 〃 〃 B = 3" DIA BUTTER'S SAMPLE
- 〃 〃 FD = FIELD DENSITY TEST SITE (SAND CONE)
- 〃 〃 TP = TEST PIT SAMPLE

NOTE: Numbers in parentheses are metric equivalents of numbers directly above.

NOTE: ALL "B" & "TW" SAMPLES SENT TO E&R CENTER FOR TESTING

Northern

Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: DH84-1 0° - 3.5'

Classification _____

Sample No. 140347

Job No. 61-114

Date July 1984

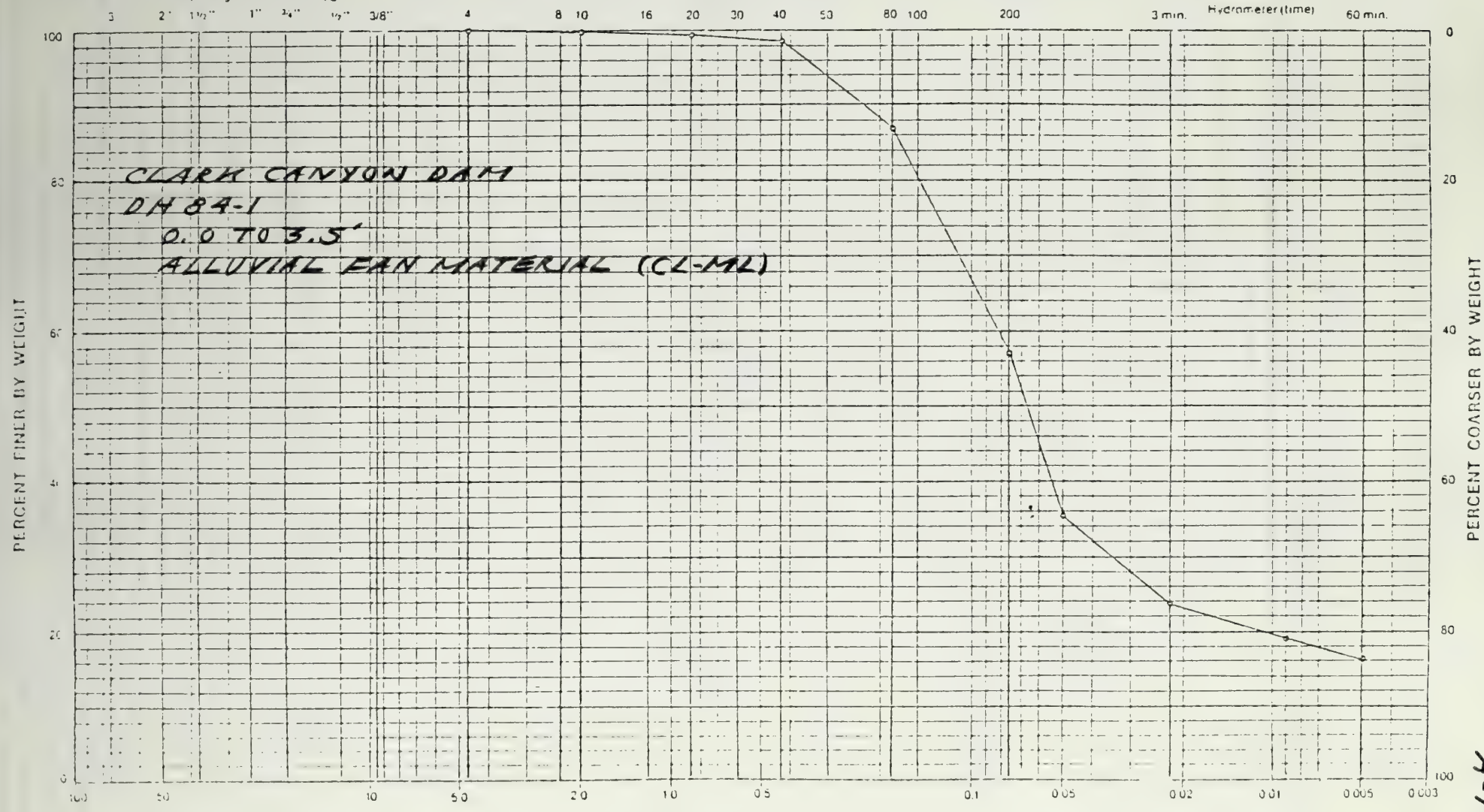
Moisture Content _____ %

Liquid Limit _____ %

Plasticity Index _____ %

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U S Standard Sieve Opening in Inches
3 2" 1½" 1" ¾" ½" 3/8" 4 8 10 16 20 30 40 50 80 100 200
U S Standard Sieve Numbers
3 min. Hydrometer (time) 60 min.
CLARK CANYON DAM
DH 84-1
0.0 TO 3.5'
ALLUVIAL FAN MATERIAL (CL-ML)
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
GRAIN SIZE IN MILLIMETERS
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

4-1

A-2

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ZONE 1 EMBANKMENT

FEATURE Clark Canyon Dam AREA _____ EXC. NO. DH84-2 DEPTH 22.5'-23.0'

SAMPLE PREPARATION

PREPARED BY L.F.K. % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11/16/84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL				160.6	391.1	683.9	
WT. PAN				0	0	0	
WET WT. RETAINED				—	—	—	_____ WET
DRY WT. RETAINED				160.6	391.1	683.9	1089.7 DRY
DRY WT. PASSING				1612.0	1381.5	1088.7	
% OF TOTAL PASSING	100	100	100	91.0	78.0	61.0	-Wt.

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{Wt}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE 11/16/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	843.5	929.1		52.0	2.380	
16	956.1	816.5		46.0	1.190	
30	1056.6	716.0		40.0	0.590	
50	1144.3	628.3		35.0	0.297	
100	1303.6	469.0		27.0	0.149	
200	1421.8	350.8		20.0	0.074	
PAN						
TOTAL	1772.6	TESTED AND COMPUTED BY LFK		CHECKED BY RJJ		DATE 11/16/84

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

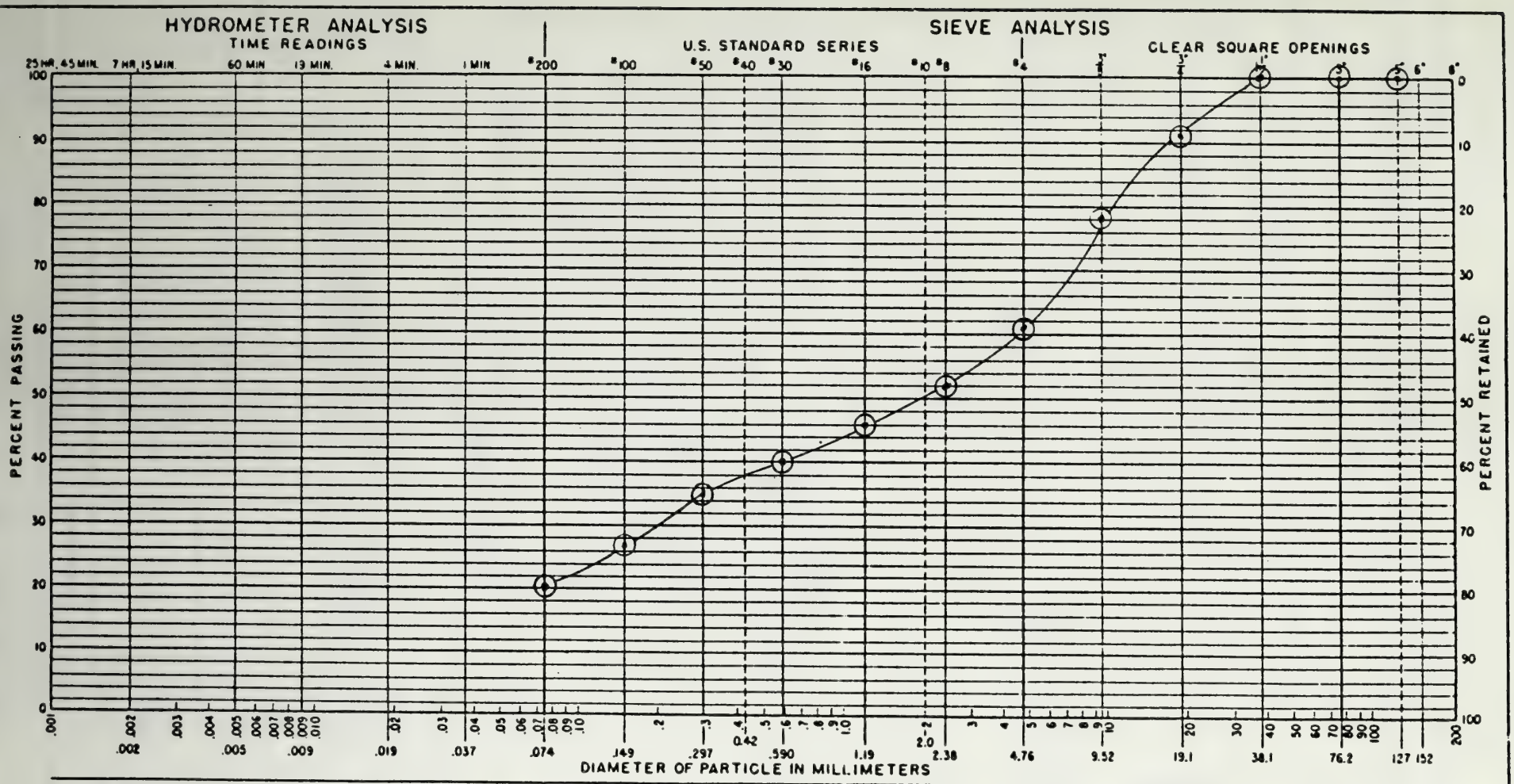
TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 837-209

DRAWN BY LFK CHECKED BY _____ DATE 11-19-84

7-1415
(3-53)



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ZONE 1 EMBANKMENT

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH 84-2 EXCAVATION No. _____ DEPTH 22.5 - 23.0 FT.

A-4

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ZONE 1 EMBANKMENT

FEATURE CLARK CANYON DAM AREA DH84-2 EXC. NO. _____ DEPTH 36.5 - 37.1'

SAMPLE PREPARATION

PREPARED BY _____ % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11/16/84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL	0	0	0	68.0	239.5	383.0	
WT. PAN				—	—	—	
WET WT. RETAINED							_____ WET
DRY WT. RETAINED				68.0	239.5	383.0	1005.9 DRY
DRY WT. PASSING				1320.9	1149.4	1005.9	
% OF TOTAL PASSING	100	100	100	95.0	83.0	73.0	-W-

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{W_2}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE 11/16/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	479.3	909.6		66.0	2.380	
16	564.7	824.2		59.0	1.190	
30	642.0	746.9		54.0	0.590	
50	730.1	658.8		47.0	0.297	
100	887.1	501.8		36.0	0.149	
200	1038.2	350.7		25.0	0.074	
PAN						
TOTAL	1388.9					

TESTED AND COMPUTED BY L.E.K. CHECKED BY R.J DATE 11/19/84

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

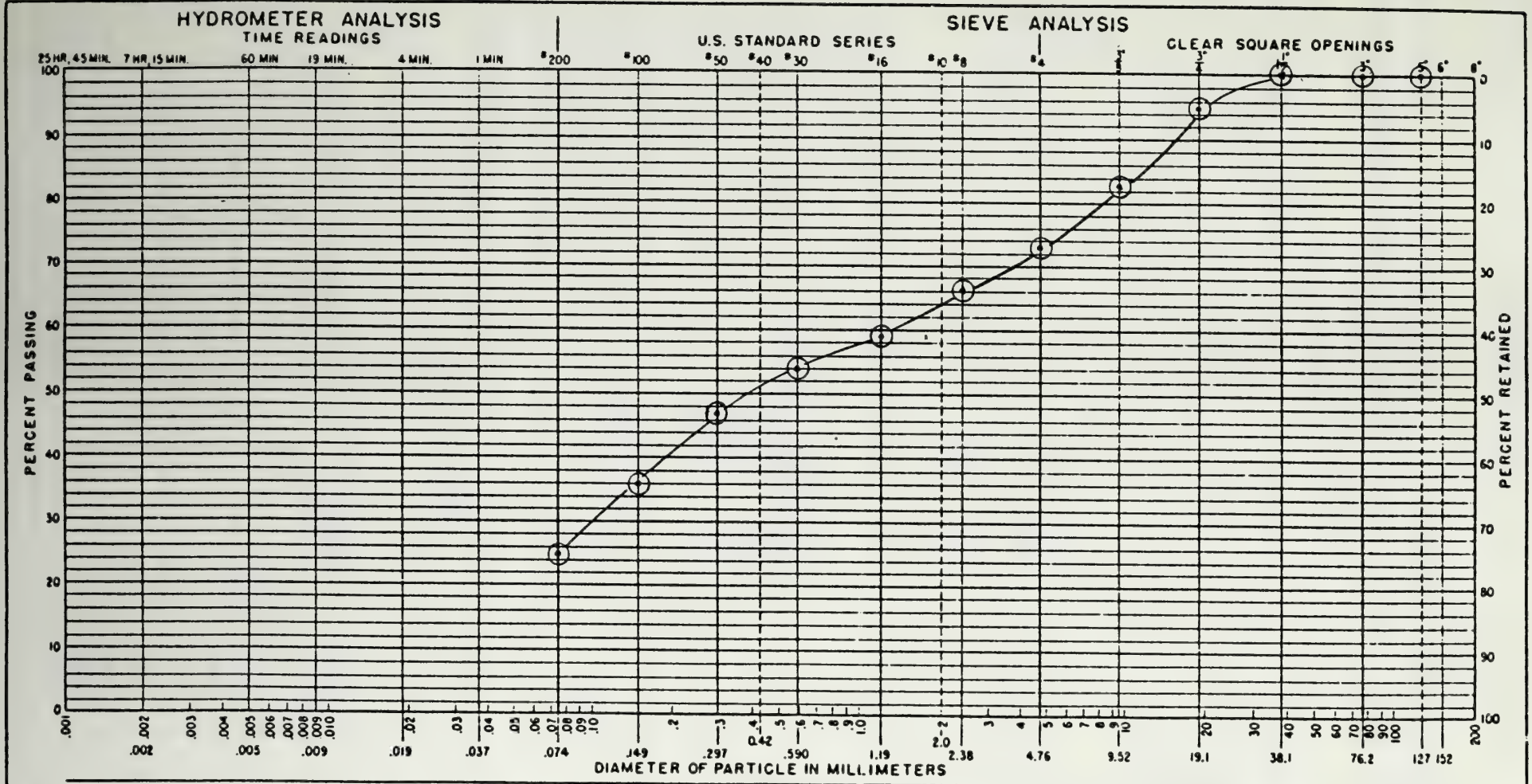
TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

*Not required for standard test.

DRAWN BY LFK CHECKED BY _____ DATE 11/19/84

7-1415 (3-53)



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ZONE 1 EMBANKMENT

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH 84-2 EXCAVATION No. _____ DEPTH 36.5 - 37.1 FT.

Interior - Reclamation - Denver, Colo.

FIGURE NO. A-5

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ZONE 1 EMBANKMENT

FEATURE CLARK CANYON DAM AREA DH 84-7 EXC. NO. _____ DEPTH 30.6 - 31.1'

SAMPLE PREPARATION

PREPARED BY _____ % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11/16/84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL	0	0	137.1	137.1	178.5	210.4	
WT. PAN							
WET WT. RETAINED							_____ WET
DRY WT. RETAINED			137.1	137.1	178.5	210.4	409.2 DRY
DRY WT. PASSING			482.5	482.5	441.1	409.2	
% OF TOTAL PASSING	100	100	78.0	78.0	71.0	66.0	-Wt.

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{W\%}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE 11/16/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	227.8	391.8		63.0	2.380	
16	236.7	382.9		62.0	1.190	
30	242.3	377.3		61.0	0.590	
50	263.1	356.5		58.0	0.297	
100	362.2	257.4		42.0	0.149	
200	448.2	171.4		28.0	0.074	
PAN						
TOTAL	619.60					

TESTED AND COMPUTED BY LEK CHECKED BY RJ DATE 11/19/84

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

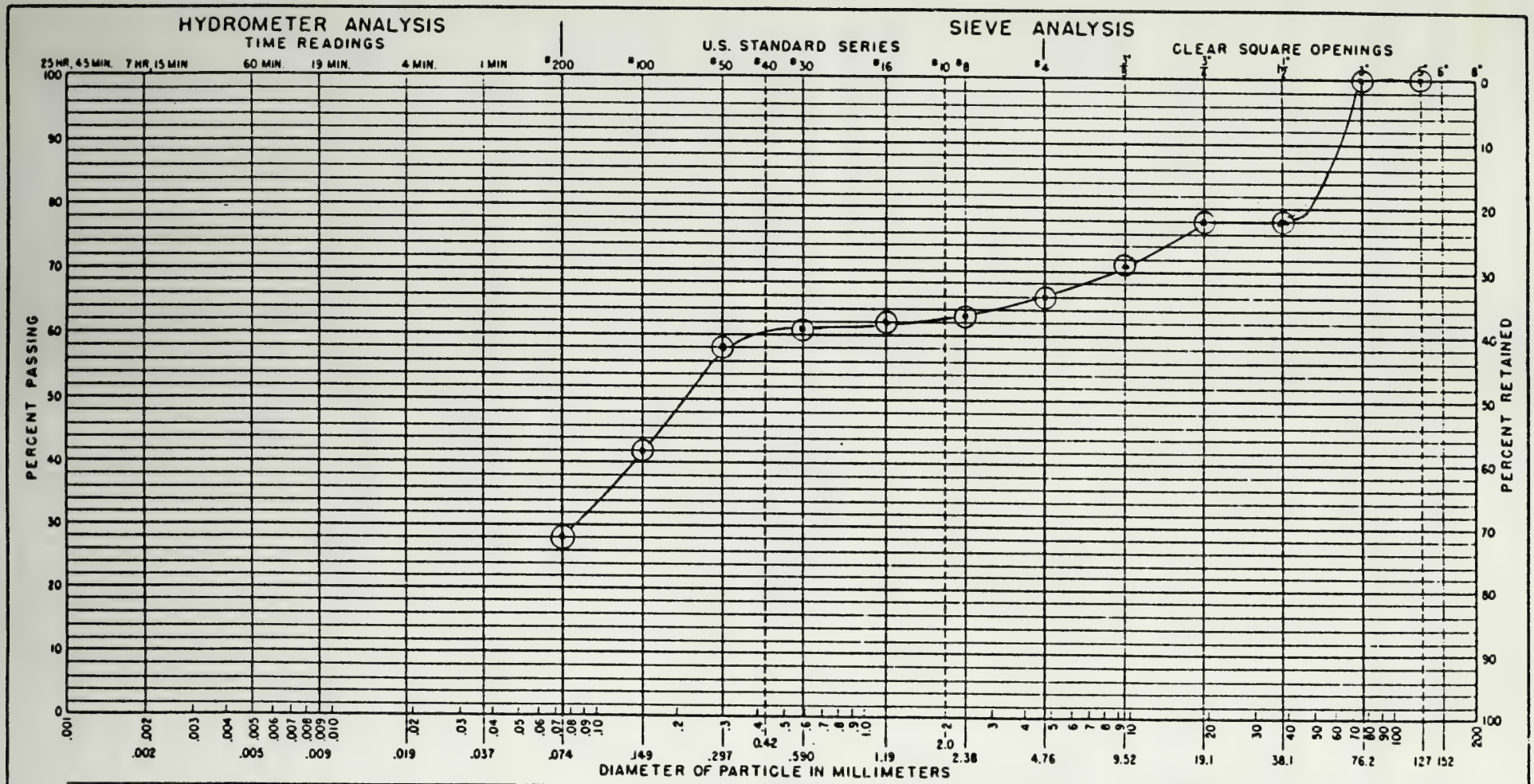
TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 837-909

DRAWN BY LFK CHECKED BY _____ DATE 11/19/84

7-1415 (3-53)


HYDROMETER ANALYSIS
TIME READINGS
25 HR, 45 MIN. 7 HR, 15 MIN 60 MIN. 19 MIN. 4 MIN. 1 MIN
SIEVE ANALYSIS
U.S. STANDARD SERIES
#200 #100 #50 #40 #30 #16 #10 #8 #4
CLEAR SQUARE OPENINGS
1 1/2" 3" 6" 8"
PERCENT PASSING
PERCENT RETAINED
100 90 80 70 60 50 40 30 20 10 0
.001 .002 .003 .004 .005 .006 .007 .008 .009 .010 .02 .03 .04 .05 .06 .07 .08 .09 .10 .2 .3 .4 .5 .6 .7 .8 .9 1.0 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200
.002 .005 .009 .019 .037 .074 .149 .297 .590 1.19 2.38 4.76 9.52 19.1 38.1 76.2 127 152
0.42
2.0
DIAMETER OF PARTICLE IN MILLIMETERS
CLAY (PLASTIC) TO SILT (NON-PLASTIC)
SAND
FINE
MEDIUM
COARSE
GRAVEL
FINE
COARSE
COBBLES

NOTES: ZONE 1 EMBANKMENT

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH 84-7 EXCAVATION No. _____ DEPTH 30.6 - 31.1 FT

Interior - Reclamation - Denver, Colo.

FIGURE NO.

4-7

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ZONE 1 EMBANKMENT

FEATURE CLARK CANYON DAM AREA OH87-7 EXC. NO. _____ DEPTH 90.6 - 90.7

SAMPLE PREPARATION

PREPARED BY L.F.K. % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE _____ % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL				32.8	92.4	136.3	
WT. PAN				—	—	—	
WET WT. RETAINED							_____ WET
DRY WT. RETAINED				32.8	92.4	136.3	378.1 DRY
DRY WT. PASSING				481.6	422.0	378.1	
% OF TOTAL PASSING	100.0	100.0	100.0	94.0	82.0	74.0	-Wo

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{W_2}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE 11/16/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	166.0	348.4		68.0	2.380	
16	185.3	329.1		64.0	1.190	
30	205.2	309.2		60.0	0.590	
50	225.0	289.4		56.0	0.297	
100	272.3	242.1		47.0	0.149	
200	317.5	196.9		38.0	0.074	
PAN						
TOTAL	514.4					

TESTED AND COMPUTED BY L.F.K. CHECKED BY RJ DATE 11/19/84

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 837-809

DRAWN BY LFK CHECKED BY _____ DATE 11/19/84

7-1415
(3-53)

HYDROMETER ANALYSIS

TIME READINGS

25 HR, 45 MIN. | 7 HR, 15 MIN. | 60 MIN | 13 MIN. | 4 MIN. | 1 MIN

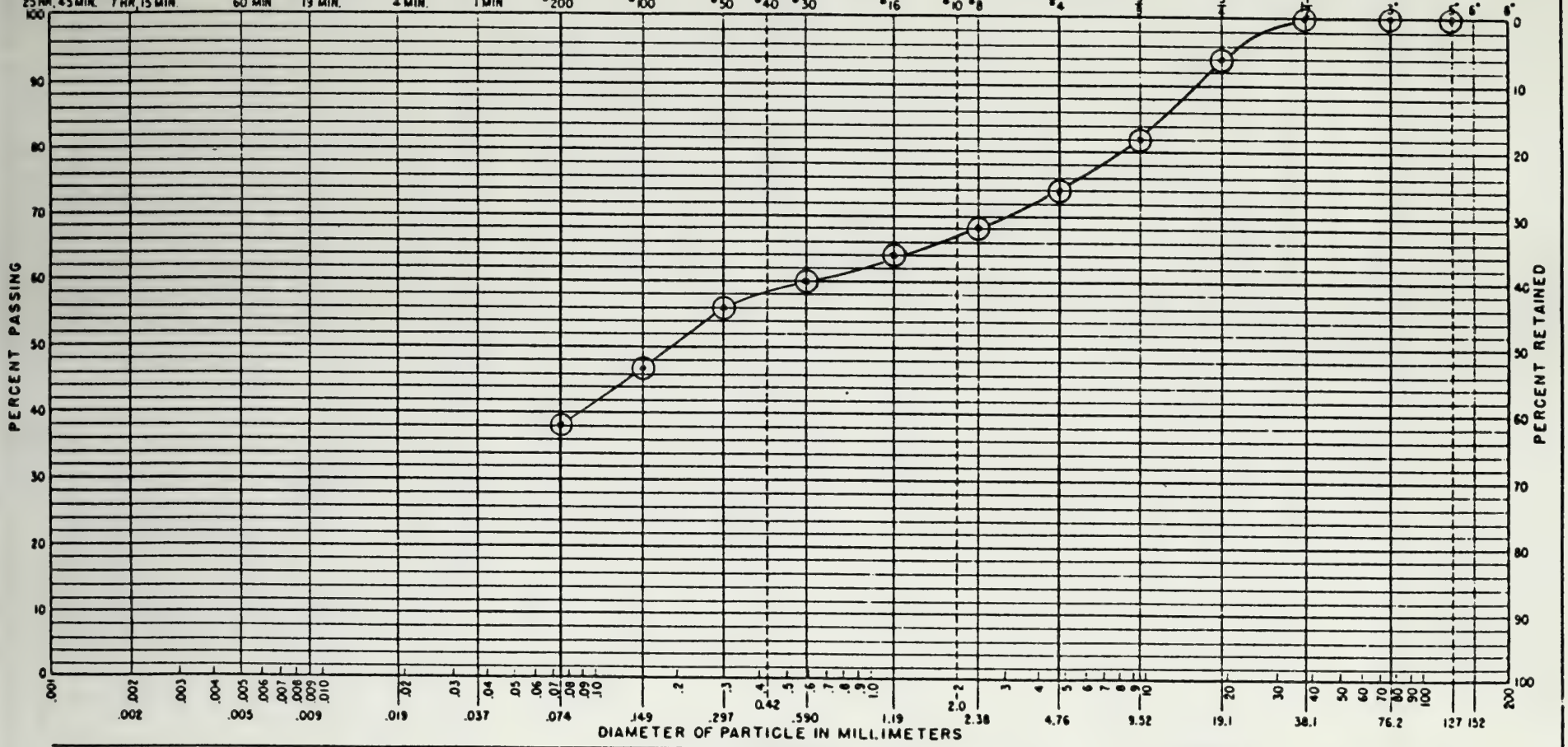
SIEVE ANALYSIS

U.S. STANDARD SERIES

#200 | #100 | #50 | #40 | #30 | #16 | #10 | #8 | #4

CLEAR SQUARE OPENINGS

1" | 3/4" | 3" | 1 1/2" | 3" | 6" | 8"



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ZONE 1 EMBANKMENT

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No _____ FIELD DESIGNATION DH 87-7 EXCAVATION No. _____ DEPTH 90.6 - 90.7 FT.

Interior - Reclamation - Denver, Colo.

FIGURE NO.

A-9

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

ALLUVIUM

LABORATORY SAMPLE NO. _____

FEATURE Clark CANYON DAM AREA DH84-7 EXC. NO. _____ DEPTH 120.6 to 121.6

SAMPLE PREPARATION

PREPARED BY LFK % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE 1043.1

DATE 11-12-84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL						57.8	
WT. PAN						—	
WET WT. RETAINED						57.8	_____ WET
DRY WT. RETAINED							_____ DRY
DRY WT. PASSING						5.5	
% OF TOTAL PASSING	100	100	100	100	100	95	-w.

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = 50.00 gms. FACTOR (F) = $\frac{W_2}{W} = \frac{95}{50} = 1.9$

DRY WT. OF SAMPLE (SIEVED) 31.49

SIEVING TIME _____ DATE 11/14/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	.62	49.38	1.9	94.0	2.380	
16	1.00	49.00		93.0	1.190	
30	1.35	48.65		92.0	0.590	
50	2.61	47.39		90.0	0.297	
100	15.81	34.19		65.0	0.149	
200	30.05	19.32		37.0	0.074	
PAN	31.34					
TOTAL	50	TESTED AND COMPUTED BY RJJ		CHECKED BY _____	DATE 11/19/84	

HYDROMETER ANALYSIS 50 grams of material

HYDROMETER NO. 10 DISPERSING AGENT Sodium Metaphosphate

STARTING TIME 1:29 DATE 11/13/84 AMOUNT 125 ml

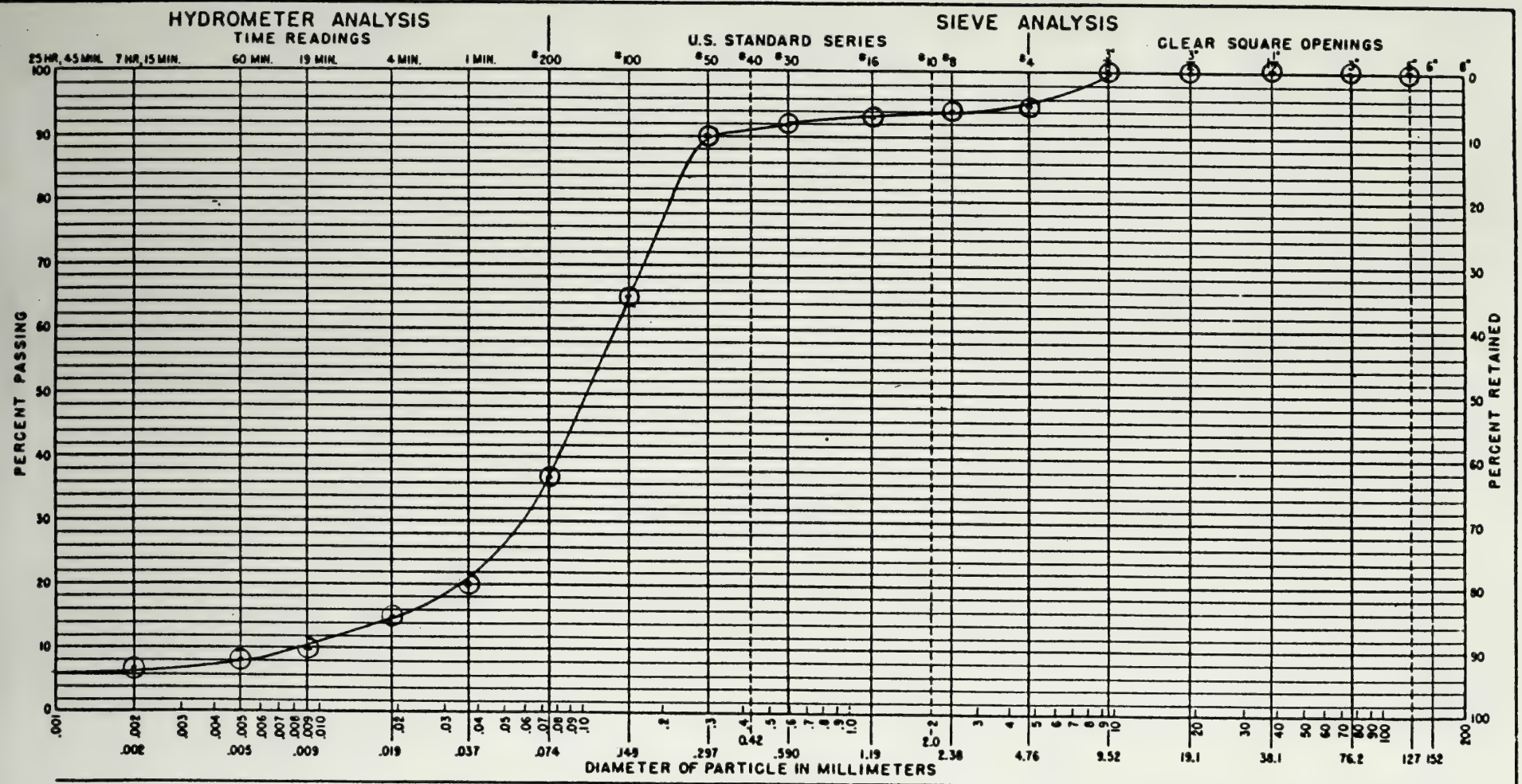
TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
~~.5 MIN*~~							0.050	
1 MIN	19	15	4½	10½		20.0	0.037	
4 MIN	19	12½	4½	8		15.0	0.019	
19 MIN	20	10	4½	5½		10.0	0.009	
60 MIN	21	8	4	4		8.0	0.005	
7 HR. 15 MIN*	21½	7½	4	3½		7.0	0.002	
25 HR. 45 MIN*							0.001	

TESTED AND COMPUTED BY RJJ CHECKED BY _____ DATE 11/19/84

*Not required for standard test.

DRAWN BY RJJ CHECKED BY _____ DATE 11/19/84

7-1415
(3-53)



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES:
ALLUVIUM

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH84-1 EXCAVATION No. _____ DEPTH 120.6 - 121.6 FT.

Interior - Reclamation - Denver, Colo.

FIGURE NO. 4-11

A-12

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. 146517 ZONE 2 EMBANKMENT

FEATURE CLARK CANYON DAM AREA PR 85-9 EXC. NO. _____ DEPTH 90.0-100'

SAMPLE PREPARATION

PREPARED BY _____ % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE _____ % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	2"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL							
WT. PAN							
WET WT. RETAINED							_____ WET
DRY WT. RETAINED							_____ DRY
DRY WT. PASSING							
% OF TOTAL PASSING		100	93	78	56	37	-#4

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{W\%}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE _____

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
10				27	~~2.380~~	
20				21	~~1.190~~	
40				16	~~0.590~~	
80				10	~~0.297~~	
~~100~~					0.149	
200				6.5	0.074	
PAN						
TOTAL						

TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

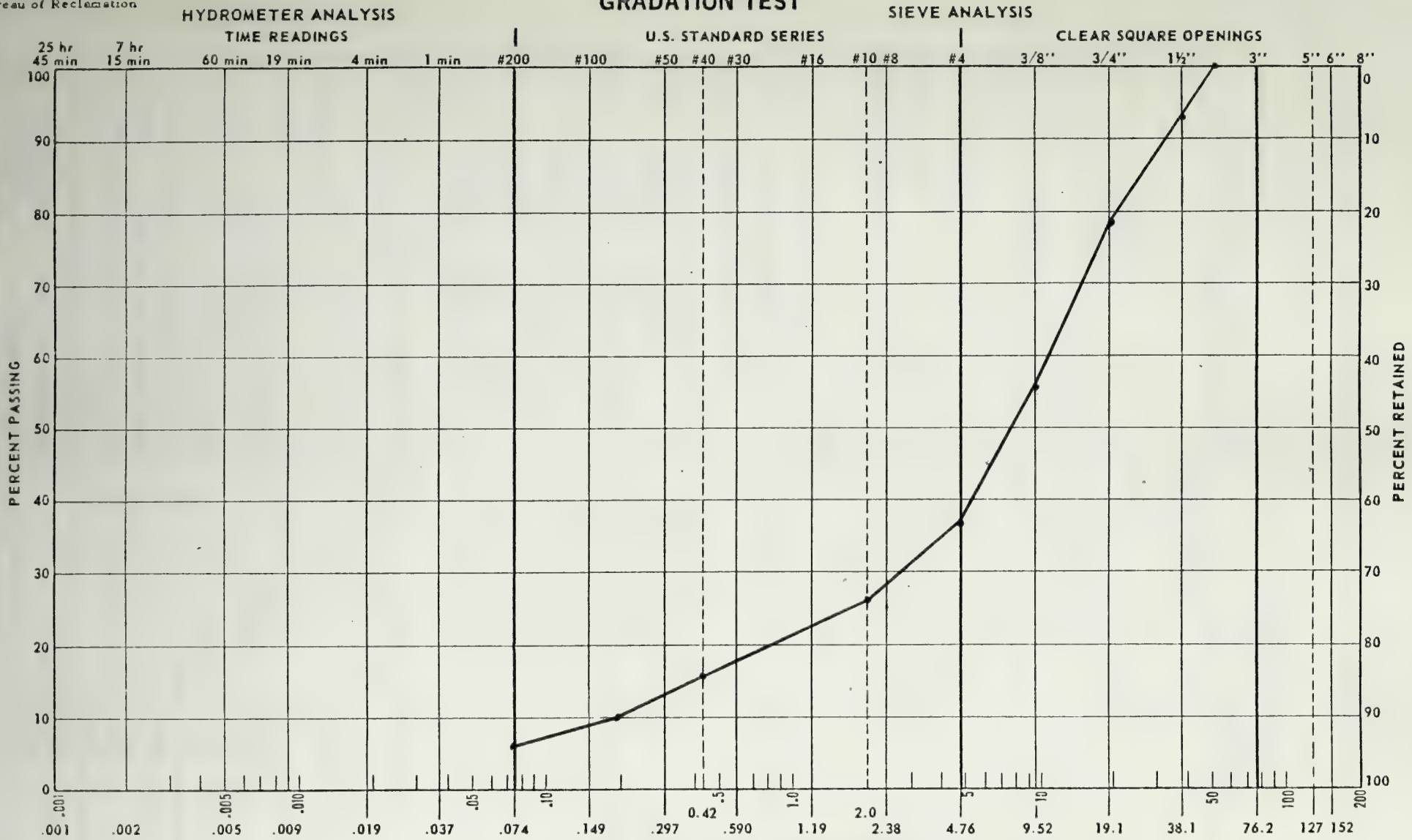
TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE 7/2/85

*Not required for standard test.

COMPLETED BY NORTHERN ENGINEERING & TESTING, INC.
BILLINGS, MONT.

7-1415 (8-70)
Bureau of Reclamation

GRADATION TEST



CLASSIFICATION SYMBOL GP

Gravel 63.0 %
Sand 30.5 %
Fines 6.5 %

ATTERBERG LIMITS
Liquid Limit _____ %
Plasticity Index _____ %
Shrinkage Limit _____ %

SPECIFIC GRAVITY
Minus No. 4 _____
Plus No. 4
Bulk _____ Apparent _____

NOTES COMPLETED BY NORTHERN ENGINEERING & TESTING, INC. BILLINGS, MONT. 7/2/85

SAMPLE NO. 146517 HOLE NO. PR 85-9 DEPTH 90.0-100.0 ft (_____ m)

CLARK CANYON DAM ZONE 2 EMBANKMENT

FIGURE 4-13

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ZONE 1 EMBANKMENT

FEATURE Clark Canyon Dam AREA _____ EXC. NO. DH84-12 DEPTH 30.5'-30.7'

SAMPLE PREPARATION

PREPARED BY L.F.K. % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11/16/84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL	0	0	0	18.0	185.0	268.8	
WT. PAN	—	—	—	—	—	—	
WET WT. RETAINED	—	—	—	—	—	—	_____ WET
DRY WT. RETAINED	0	0	0	18.0	185.0	268.8	_____ DRY
DRY WT. PASSING	635.6	635.6	635.6	617.0	450.6	366.8	
% OF TOTAL PASSING	100.0	100.0	100.0	97.0	71.0	58.0	$-W_2$

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = _____ gms. FACTOR (F) = $\frac{W_2}{W}$ = _____ = _____

DRY WT. OF SAMPLE (SIEVED) _____

SIEVING TIME _____ DATE 11/16/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	304.4	331.2		52.0	2.380	
16	325.2	310.4		49.0	1.190	
30	341.1	294.5		46.0	0.590	
50	358.8	276.8		44.0	0.297	
100	415.6	220.0		35.0	0.149	
200	478.8	156.8		25.0	0.074	
PAN						
TOTAL	635.6					

TESTED AND COMPUTED BY L.F.K. CHECKED BY W.J.K. DATE 11/19/84

HYDROMETER ANALYSIS

HYDROMETER NO. _____ DISPERSING AGENT _____

STARTING TIME _____ DATE _____ AMOUNT _____ ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*							0.050	
1 MIN							0.037	
4 MIN							0.019	
19 MIN							0.009	
60 MIN							0.005	
7 HR. 15 MIN*							0.002	
25 HR. 45 MIN*							0.001	

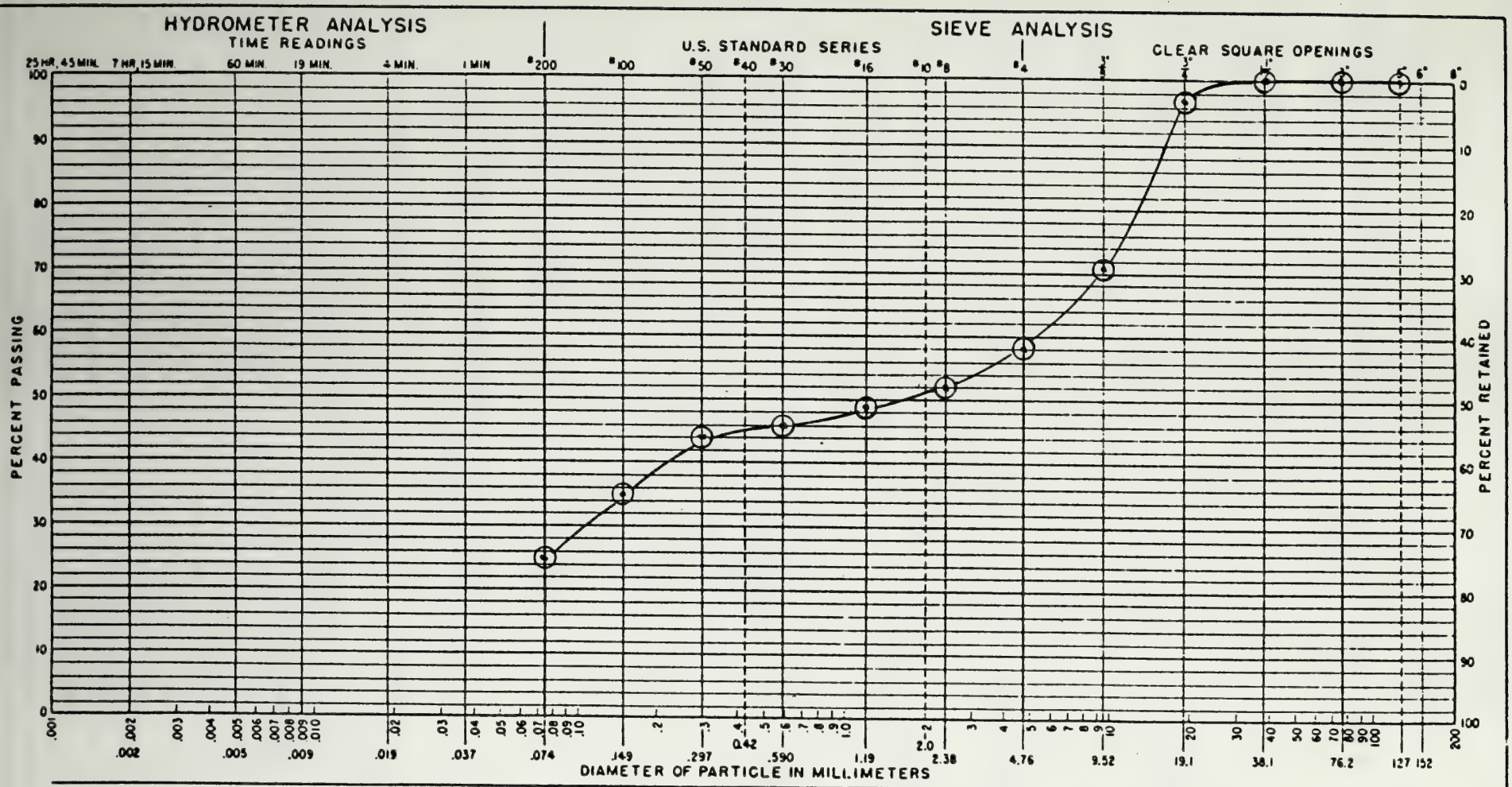
TESTED AND COMPUTED BY _____ CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 831-399

DRAWN BY LFK CHECKED BY _____ DATE 11/19/84

7-1415
(3-53)



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ZONE 1 EMBANKMENT

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH84-12 EXCAVATION No. _____ DEPTH 30.5 - 30.7 FT.

Interior - Reclamation - Denver, Colo.

FIGURE NO. 4-15

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

LABORATORY SAMPLE NO. _____ ALLUVIAL FAN

FEATURE Clark Canyon Dam AREA DH84-12 EXC. NO. _____ DEPTH 80.5 to 81.4

SAMPLE PREPARATION

PREPARED BY LFK % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE 5.41 - 1.73 = 3.68

DATE 11/12/84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL	0	0	0	2.05	2.33	2.52	
WT. PAN	0	0	0	1.73	1.73	1.73	
WET WT. RETAINED	0	0	0	—	—	—	— WET
DRY WT. RETAINED				0.32	0.60	0.79	2.89 DRY
DRY WT. PASSING				3.36	3.08	2.89	
% OF TOTAL PASSING	100	100	100	91.0	84.0	79.0	- W%

SIEVE AND HYDROMETER ANALYSIS

DISH NO. _____ DRY WT. OF SAMPLE (W) = 50 gms. FACTOR (F) = $\frac{W_2}{W} = \frac{79}{50} = 1.58$

DRY WT. OF SAMPLE (SIEVED) 31.45

SIEVING TIME _____ DATE 11/14/84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	4.70	45.30		72.0	2.380	
16	2.64 7.34	42.66		68.0	1.190	
30	9.40	40.60		64.0	0.590	
50	12.93	37.07		59.0	0.297	
100	22.48	27.52		43.0	0.149	
200	31.27	18.73		30.0	0.074	
PAN	.18					
TOTAL	50.00					

TESTED AND COMPUTED BY RJJ CHECKED BY _____ DATE 11/15/84

HYDROMETER ANALYSIS

HYDROMETER NO. 152H - 51368 DISPERSING AGENT Sodium Metaphosphate

STARTING TIME 11:14 DATE 11/13/84 AMOUNT 125 ml

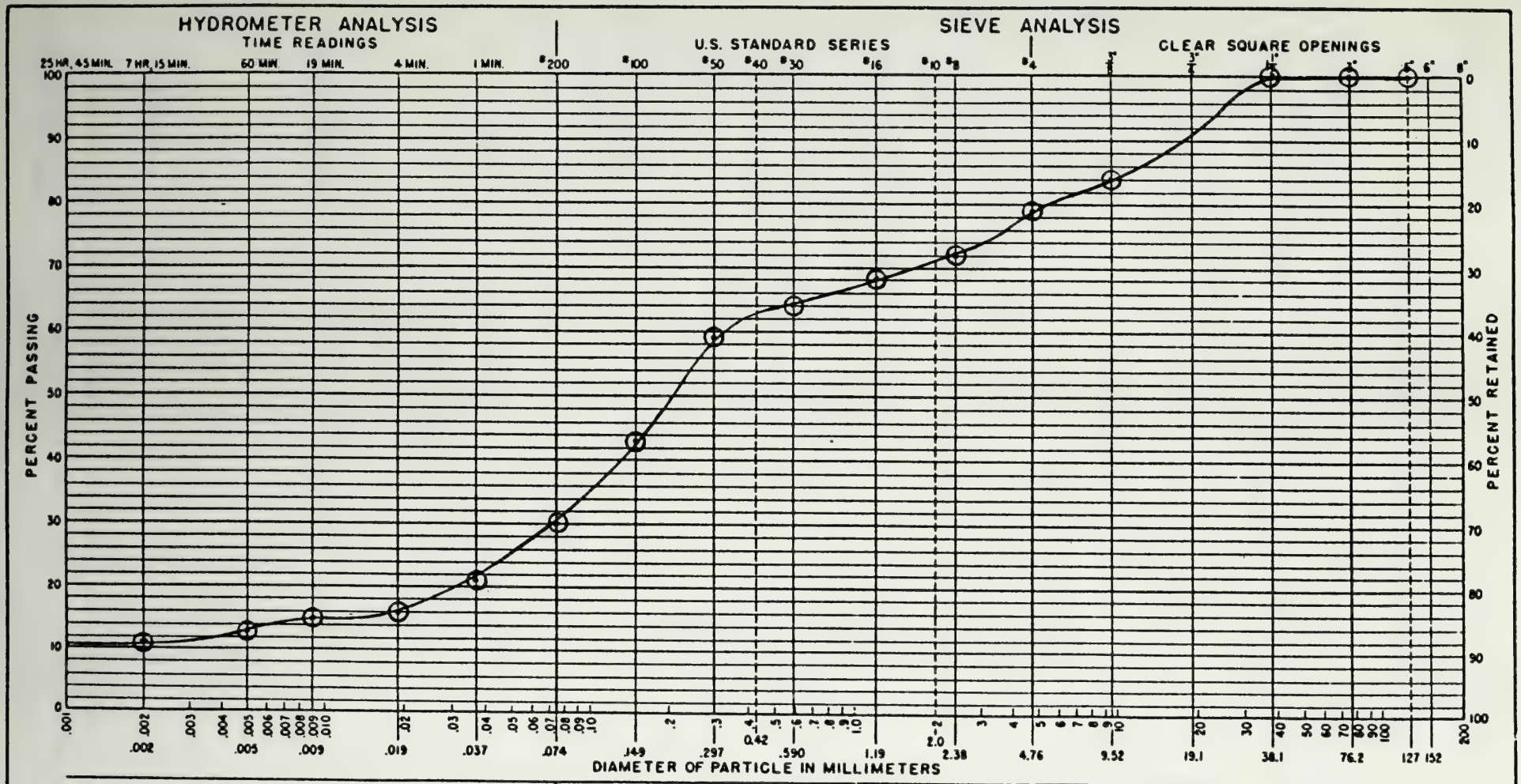
TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
~~1.5 MIN~~							0.050	
1 MIN	19	18	4 1/2	13 1/2		21.0	0.037	
4 MIN	19	15	4 1/2	10 1/2		16.0	0.019	
19 MIN	20	14	4 1/2	9 1/2		15.0	0.009	
60 MIN	21	12 1/2	4	8 1/2		13.0	0.005	
7 HR. 15 MIN*	21 1/2	11	4	7		11.0	0.002	
25 HR. 45 MIN*							0.001	

TESTED AND COMPUTED BY RJJ CHECKED BY _____ DATE 11/15/84

*Not required for standard test.

DRAWN BY RJJ CHECKED BY _____ DATE 11/15/84

7-1415
(3-53)



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

NOTES: ALLUVIAL FAN

GRADATION TEST

CLARK CANYON DAM

LABORATORY SAMPLE No. _____ FIELD DESIGNATION DH84-12 EXCAVATION No. _____ DEPTH 80.5 - 81.4 FT.

Interior - Reclamation - Denver, Colo.

FIGURE NO. 4-17

7-1656
3-59
Bureau of Reclamation

UNDISTURBED SOIL SAMPLING DATA

Hole No. DH84-2 Feature CLARK CANYON DAM
Ground elev. 5579.85 Project EAST BENCH UNIT
Water table elev. _____ Foreman L. THOMAS
Location STA. 19+00, 8' U.S.

Date	9-7-84			
Sample No.	1			
Sample depth	90.6-92.5			
Sampler type	5" Thinwall			
Sampler Tube No.	249			
I.D. bit	0.330			
Inside area, bit (sq ft)	0.119			
Initial penetration	0.40			
Drive length	1.50			
Total penetration	1.90			
Sample recovery length	1.90			
Sample recovery (%)	100			
Trimmed sample length	1.70			
Volume of sample (cu ft)	0.20			
Wt of tube +soil	44.41			
Wt of tube	17.06			
Wt of wet soil	27.35			
Moisture content (%)	11.3			
Dry density (pcf)	122.85			
Soil classification	SILTY SAND Approx. 50% fine to coarse sand; 30% gravel to 1½"; 20% non-plastic fines. (SM)			
Remarks	Rock caved in bottom 3 feet of hole in sample.			

Note: All dimensions in feet and weight in pounds unless otherwise indicated.

GPO 859169

Suspect some compression in all samples.

7-1656
3-59
Bureau of Reclamation

UNDISTURBED SOIL SAMPLING DATA

Hole No. DH 84-7 Feature CLARK CANYON DAM
Ground elev. 5579.83 Project EAST BENCH UNIT
Water table elev. Foreman L. THOMAS
Location STA. 24+50, 8' U.S.

Date	9-15-84	9-16-84	9-17-84	
Sample No.	1	2	3	
Sample depth	60.6-62.25	120.6-121.6	125.6-127.8	
Sampler type	5" Thinwall	5" Thinwall	5" Thinwall	
Sampler Tube No.	205	209	97B	
I. D. bit	0.390	0.390	0.385	
Inside area, bit (sq ft)	0.119	0.119	0.116	
Initial penetration	0.15	0.70	0.70	
Drive length	1.5	0.30	1.50	
Total penetration	1.65	1.00	2.20	
Sample recovery length	1.65	1.00	2.20	
Sample recovery (%)	100	100	100	
Trimmed sample length	1.47	0.49	2.12	
Volume of sample (cu ft)	0.175	0.058	0.246	
Wt of tube +soil	40.67	25.27	50.91	
Wt of tube	17.05	17.04	16.62	
Wt of wet soil	23.62	8.23	34.29	
Moisture content (%)	14.9	AVG. 14.85*	13.2	
Dry density (pcf)	117.49	123.62	123.13	
Soil classification	CLAYEY SAND Approx. 50% sand; 40% clay; 10% gravel. (SC)	TOP: SAND fine, saturated, clean. (SP) BOTTOM: CLAYEY SAND 60% sand; 20% gravel; 20% clay. (SC)	CLAYEY SAND 25% clay, some gravel. (SC)	
Remarks	Bottom of tube bent. Void along side.	Bottom of tube bent. Missed most of sand zone.	Bottom of tube bent.	

Note: All dimensions in feet and weight in pounds unless otherwise indicated.

GPO 890169

* Top moisture 18.0%
Bottom moisture 11.7%

Suspect some compression in all samples.

7-1656
3-59
Bureau of Reclamation

UNDISTURBED SOIL SAMPLING DATA

Hole No. DH84-12 Feature CLARK CANYON DAM
Ground elev. 5579.62 Project EAST BENCH UNIT
Water table elev. Foreman L. THOMAS
Location STA. 17+00, 8' U.S.

Date	9-21-84	9-22-84	9-22-84	
Sample No.	1	2	3	
Sample depth	66.1-68.1	68.9-70.45	89.3-92.07	
Sampler type	5" Thinwall	5" Thinwall	5" Thinwall	
Sampler Tube No.	88B	40F	1C	
I. D. bit	0.390	0.390	0.390	
Inside area, bit (sq ft)	0.119	0.119	0.119	
Initial penetration	1.00	0.65	1.27	
Drive length	1.50	0.90	1.50	
Total penetration	2.50	1.55	2.77	
Sample recovery length	2.50	1.55	2.77	
Sample recovery (%)	100	100	100	
Trimmed sample length	2.30	1.40	2.65	
Volume of sample (cu ft)	0.274	0.167	0.315	
Wt of tube +soil	54.45	41.71	58.43	
Wt of tube	17.66	18.12	17.50	
Wt of wet soil	36.79	23.59	40.93	
Moisture content (%)	17.2	Avg. 14.6	21.2	
Dry density (pcf)	114.56	123.23	107.21	
Soil classification	SILTY SAND fine, some fine gravel, about 15% silt. (SM)	Top: SILTY SAND (SM) Bottom: SILTY SAND with gravel and cobbles (SM)	SAND clean, fine, saturated. (SP)	
Remarks	Top may contain cave. Void along side.	Top moisture 20.4% Bott. moisture 8.8%	Sample loose in tube.	

Note: All dimensions in feet and weight in pounds unless otherwise indicated.

GPO 821160

Suspect some compression in all samples.

Project Clark Canyon Dam

Project No. _____ Date 5-21-85

Driller J. McLaughlin

Geologist
~~Inspector~~ F. Calcagno

Tube OD _____ Tube ID 709

Cutting edge dia. at ¼ points _____ Clearance Ratio _____

FIELD THIN-WALL TUBE LOG - STATIONARY FIXED PISTON SAMPLER

Boring DH 85-3A Sample #1

Depth 5.3 to 6.8

Penetration 1.52'

Recovery - Gross 1.42'

Net 1.42'

Length of testable sample 1.32' (trimmed)

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 4.5'

Depth to bottom of hole 5.23

Method of advancement Bx drive

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 5.23

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0.02

Total penetration 1.52

Hydraulic pressure 90 psi to 100 psi at end.

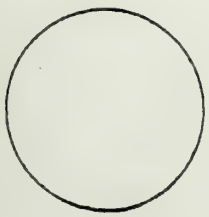
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? no

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.1'

c) packer 0

Type of packer plastic w/flexible o-ring

Description of bottom cuttings Silty sand

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: Sheared bottom with two manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 1.00'

b) soil before trimming 1.65'

c) soil after trimming 1.75'

d) packer 1.71'

Type of packer plastic with flexible o-ring

GENERAL NOTES:

Weight of soil: 5.83 lbs.
Wet density: 101.1
Dry density: 82.8

Project Clark Canyon Dam

Project No. _____ Date 5-21-85

Driller J. McLaughlin

Geologist
Inspector F. Calcagno

Tube OD _____ Tube ID 701

Cutting edge dia. at ¼ points _____ Clearance Ratio _____

FIELD THIN-WALL TUBE LOG - STATIONARY FIXED PISTON SAMPLER

Boring DH 85-3A Sample #2

Depth 6.8 to 8.3

Penetration 1.53'

Recovery - Gross 1.39'

Net 1.39'

Length of testable sample 1.29' (trimmed)

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 4.5'

Depth to bottom of hole 6.8

Method of advancement 2-15/16" rock bit

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 6.8

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0.01'

Total penetration 1.53'

Hydraulic pressure 50 psi and ended at 100 psi.

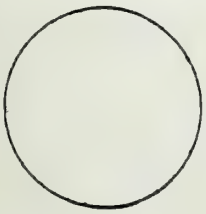
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? no

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.10'

c) packer 0

Type of packer plastic w/flexible o-ring

Description of bottom cuttings _____

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: Sheared bottom with two manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.3'

b) soil before trimming 1.61'

c) soil after trimming 1.61'

d) packer 1.59'

Type of packer plastic with flexible o-ring.

GENERAL NOTES:

Weight of soil: 6.57 lbs.
Wet density: 116.6

Dry density: 95.6

Project Clark Canyon Dam

Project No. _____ Date 5-29-85

Driller J. McLaughlin

Geologist
~~Inspector~~ F. Calcagno

FIELD THIN-WALL TUBE LOG -
STATIONARY FIXED PISTON SAMPLER

Boring DH 85-3A Sample #3

Depth 22.0 to 23.1

Penetration 1.14'

Recovery - Gross 0

Net 0

Length of testable sample 0

Tube OD _____ Tube ID 713

Cutting edge dia. at ¼ points _____ Clearance Ratio _____

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 21.5'

Depth to bottom of hole 22.0

Method of advancement 2-15/16" rock bit

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 22.0'

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.14'

Hydraulic pressure 100 psi to 200 psi at end.

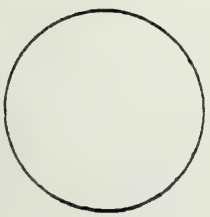
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? _____

Distance from bottom of tube to:

a) soil before trimming _____

b) soil after trimming _____

c) packer _____

Type of packer _____

Description of bottom cuttings _____

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft -

Comments:

TOP OF TUBE

Dist from tube bottom to piston _____

Distance from top of tube to:

a) fluid above soil _____

b) soil before trimming _____

c) soil after trimming _____

d) packer _____

Type of packer _____

GENERAL NOTES: Soil interval sampled was too rocky; lost sample.

Project Clark Canyon Dam

Project No. _____ Date 7-24-85

Driller J. McLaughlin

Geologist
~~Inspector~~ F. Calcagno

Tube OD _____ Tube ID 728

Cutting edge dia. at 4 points _____ Clearance Ratio 0

FIELD THIN-WALL TUBE LOG - STATIONARY FIXED PISTON SAMPLER

Boring PR 85-3B Sample #1

Depth 6.6 to 7.1

Penetration 0.5

Recovery - Gross 0.5

Net _____

Length of testable sample 0.46

ADVANCEMENT OF HOLE

Casing size & depth 4" @ 6.2'

Depth to bottom of hole 6.6

Method of advancement 3-7/8" rock bit

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 6.6

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 0.5

Hydraulic pressure started at 80 and stopped at 200 psi

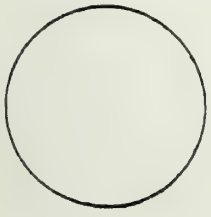
Rate of penetration Constant during push.

Mvmt of act rods during push 0

Comments on push: Material very hard to push. Also, locking mechanism on inner rod locked on shaft after 0.5' of push. Same happened in previous attempt

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? no

Distance from bottom of tube to:

a) soil before trimming 0.25

b) soil after trimming 0.27

c) packer 0

Type of packer plastic w/flex. "O" ring

Description of bottom cuttings silty sand (fne to medium sand)

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: Sheared bottom with two Manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 1.1'

b) soil before trimming 2.25'

c) soil after trimming 2.27'

d) packer 2.21'

Type of packer plastic with flexible "O" ring.

GENERAL NOTES:

Weight of soil: 2.31 lbs.
Wet density: 114.9
Dry density: 97.2

Project Clark Canyon Dam

Project No. _____ Date 7-24-85

Driller J. McLaughlin

Geologist
Inspector F. Calcagno

FIELD THIN-WALL TUBE LOG -
STATIONARY FIXED PISTON SAMPLER

Boring PR 85-3B Sample #2

Depth 7.1 to 9.0

Penetration 1.9

Recovery - Gross 1.9

Net 1.9

Length of testable sample 0.95

Tube OD _____ Tube ID 706

Cutting edge dia. at ¼ points _____ Clearance Ratio 0

ADVANCEMENT OF HOLE

Casing size & depth 4" @ 6.2'

Depth to bottom of hole 7.1

Method of advancement prev. butter

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 7.1

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.9

Hydraulic pressure start at 80 to 180 psi at end

Rate of penetration _____

Mvmt of act rods during push 0

Comments on push: good

Mvmt of act rods after release 0

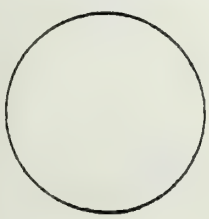
Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: Sheared bottom with two manual turns.

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? No

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.13'

c) packer _____

Type of packer plastic w/flex. "0" ring

Description of bottom cuttings silty sand

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.5'

b) soil before trimming 1.1'

c) soil after trimming 1.92'

d) packer 1.87'

Type of packer plastic with flexible "0" ring.

GENERAL NOTES:

Weight of soil: 4.48 lbs.

Wet density: 107.9

Dry density: 93.6

Project Clark Canyon Dam

Project No. _____ Date 7-25-85

Driller J. McLaughlin

Geologist Inspector F. Calcagno

Tube OD _____ Tube ID 720

Cutting edge dia. at 4 points _____ Clearance Ratio 0

FIELD THIN-WALL TUBE LOG - STATIONARY FIXED PISTON SAMPLER

Boring PR 85-3B Sample #3

Depth 18.0 to 19.8

Penetration 1.8

Recovery - Gross 1.8

Net 1.8

Length of testable sample 1.55

ADVANCEMENT OF HOLE

Casing size & depth 4" @ 18.0'

Depth to bottom of hole 18.0

Method of advancement 3-7/8" rock bit

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 18.0

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.8

Hydraulic pressure from 100 to 200 psi at end.

Rate of penetration _____

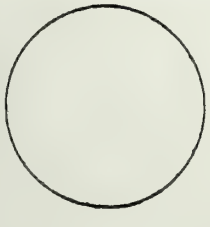
Mvmt of act rods during push 0

Comments on push:

good

BOTTOM OF TUBE

Condition of cutting edge - sketch



had to file edge smooth

Pliers used to repair cutting edge? _____

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.1'

c) packer 0

Type of packer plastic w/flex. "O" ring

Description of bottom cuttings silty sand (sand is fine to medium)

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: Sheared bottom with two manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.6'

b) soil before trimming 1.2'

c) soil after trimming 1.35'

d) packer 1.27'

Type of packer plastic with flexible "O" ring

GENERAL NOTES:

Weight of soil: 9.34'

Wet density: 137.9

Dry density: 111.3

Project Clark Canyon Dam

Project No. _____ Date 7-25-85

Driller J. McLaughlin

Geologist
~~Inspector~~ F. Calcagno

FIELD THIN-WALL TUBE LOG -
STATIONARY FIXED PISTON SAMPLER

Boring PR 85-3B Sample #4

Depth 19.8 to 21.9

Penetration 2.1

Recovery - Gross 2.1

Net 2.1'

Length of testable sample 1.97'

Tube OD _____ Tube ID 703

Cutting edge dia. at ¼ points _____ Clearance Ratio 0

ADVANCEMENT OF HOLE

Casing size & depth 4" @ 18.0'

Depth to bottom of hole 19.8'

Method of advancement Prev. Butter

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 19.8

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 0

Hydraulic pressure started with 50 to 240 psi at end.

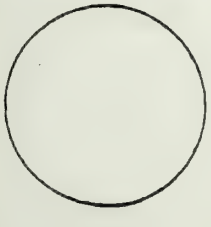
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push: good

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? No

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.12

c) packer _____

Type of packer plastic w/flex. "O" ring

Description of bottom cuttings _____

Silty sand (fine to medium sand)

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: sheared bottom with two manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.2'

b) soil before trimming 0.9'

c) soil after trimming 0.91'

d) packer 0.86'

Type of packer plastic with flexible "O" ring

GENERAL NOTES:

Weight of soil: 10.71

Wet density: 124.4

Dry density: 105.3

Project Clark Canyon Dam

Project No. _____ Date 5-30-85

Driller J. McLaughlin

Geologist
Inspector F. Calcagno

Tube OD _____ Tube ID 704

Cutting edge dia. at ¼ points _____ Clearance Ratio 0

FIELD THIN-WALL TUBE LOG - STATIONARY FIXED PISTON SAMPLER

Boring DH 85-11A Sample #1

Depth 6.1 to 7.4

Penetration 1.3

Recovery - Gross 1.3

Net 1.3

Length of testable sample 1.07 (trimmed)

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 5.1'

Depth to bottom of hole 6.1

Method of advancement 3-7/8" rock bit

Thickness of wash at bottom of hole before lowering tube 0

Tube lowered to 6.1'

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.3

Hydraulic pressure 95 psi constant

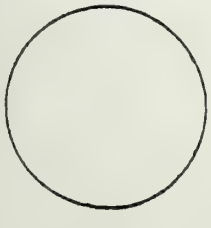
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:
good

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair cutting edge? No

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.1

c) packer 0

Type of packer plastic w/flexible O-ring

Description of bottom cuttings _____
silty sand

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial 2 ft hydraulic

Comments: sheared bottom with two manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.9'

b) soil before trimming 1.80'

c) soil after trimming 1.83'

d) packer 1.77'

Type of packer plastic with flexible "O"-ring.

GENERAL NOTES:

Weight of soil: 5.29 lbs.
Wet density: 113.1
Dry density: 74.4

Project Clark Canyon Dam

Project No. _____ Date 5-30-85

Driller J. McLaughlin

Geologist
~~Inspector~~ F. Calcagno

FIELD THIN-WALL TUBE LOG -
STATIONARY FIXED PISTON SAMPLER

Boring DH 85-11A Sample #2

Depth 7.5 to 9.2

Penetration 1.70

Recovery - Gross 1.70

Net 1.70

Length of testable sample 1.55
(trimmed)

Tube OD _____ Tube ID 712

Cutting edge dia. at
4 points _____ Clearance
Ratio 0

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 5.1'

Depth to bottom of hole 7.5

Method of advancement 3-7/8" rock bit

Thickness of wash at bottom of
hole before lowering tube 0

Tube lowered to 7.5'

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.70

Hydraulic pressure 90 psi constant

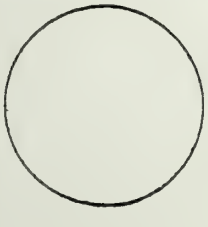
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:
good

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair
cutting edge? No

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.1'

c) packer 0

Type of packer plastic w/flexible O-ring

Description of bottom cuttings _____
silty sand

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial
2 ft hydraulic

Comments: sheared bottom with two
manual turns.

TOP OF TUBE

Dist from tube bottom to piston 1/32"

Distance from top of tube to:

a) fluid above soil 0.5'

b) soil before trimming 1.30'

c) soil after trimming 1.35'

d) packer 1.28'

Type of packer plastic with flexible
O-ring.

GENERAL NOTES: Some gravel on top of sample from cleaning out casing.
Weight of soil: 8.00 lbs.

Wet density: 118.1 Dry density: 86.5

Project Clark Canyon Dam

Project No. _____ Date 5-30-85

Driller J. McLaughlin

Geologist
Inspector F. Calcagno

FIELD THIN-WALL TUBE LOG -
STATIONARY FIXED PISTON SAMPLER

Boring DH 85-11A Sample #3

Depth 9.2 to 10.4

Penetration 1.2'

Recovery - Gross 1.2'

Net 1.2'

Length of testable sample 1.09'
(trimmed)

Tube OD _____ Tube ID 707

Cutting edge dia. at
4 points _____ Clearance
Ratio 0

ADVANCEMENT OF HOLE

Casing size & depth 4.5" @ 5.1'

Depth to bottom of hole 9.2

Method of advancement Butter tube

Thickness of wash at bottom of
hole before lowering tube 0

Tube lowered to 9.2

Rod size _____

Comments:

PENETRATION & REMOVAL OF SAMPLER

Penetration from weight of rods 0

Total penetration 1.2'

Hydraulic pressure 95 psi constant

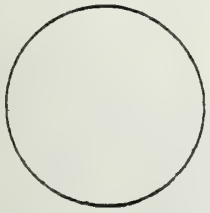
Rate of penetration _____

Mvmt of act rods during push 0

Comments on push:

BOTTOM OF TUBE

Condition of cutting edge - sketch



Pliers used to repair
cutting edge? No

Distance from bottom of tube to:

a) soil before trimming 0

b) soil after trimming 0.1'

c) packer 0

Type of packer plastic w/flex. "O"-ring

Description of bottom cuttings _____

Clayey sand

Mvmt of act rods after release 0

Mvmt of act rods supports 0

Method for lifting tube initial
2 ft hydraulic

Comments: sheared bottom with two
manual turns.

TOP OF TUBE

Dist from tube bottom to piston 0

Distance from top of tube to:

a) fluid above soil 0.3'

b) soil before trimming 1.80'

c) soil after trimming 1.81'

d) packer 1.75'

Type of packer plastic with flexible
"O"-ring.

GENERAL NOTES:

Weight of soil: 5.38 lbs.
Dark gray, coarse clayey sand on bottom; couldn't penetrate any further.

Wet density: 113.0 Dry density: 78.7

A-31

United States Department of the Interior

BUREAU OF RECLAMATION
Deerfield Dam Construction Office
P.O. Box 108
Hill City, South Dakota 57745

IN REPLY
REFER TO:

DEC 3 1984
NO REPLY NECESSARY
INITIAL DATE

200		
220	EL	7
230	PJM	12-10
240		

NOV 30 1984

Memorandum

To: Regional Director, Billings, MT
Attn: UM-220

From: Project Construction Engineer

Subject: Transmittal of Test Data on Sandy Silt near Drill Hole DH-84-~~14~~ 13 at Clark Canyon Dam, Dillon, Montana

Enclosed are the results on proctor density tests taken on the sandy silt near drill hole DH-84-~~14~~ 13.

The original sheets on the tests performed will be sent to your inspector in Dillon.

Keith R. Barnes

Enclosures

cc: Assistant Commissioner, Engineering and Research
Attn: D-230 (John Cyganiewicz)

Pat McDermott
East Bench Irrigation District
1100 Hwy 41
Dillon, Montana 59725

NOTE: DH 84-14 CHANGED TO DH 84-13

A-32

7-1451 (8-72)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

DH 84-13

I.P.D. 10' D/S of ~~DH 84-14~~ (11 2-

LABORATORY SAMPLE NO. _____

FEATURE Clark canyon Dam AREA _____ EXC. NO. CCDF-1 DEPTH 1.1' To 2.1'

SAMPLE PREPARATION

PREPARED BY BLS % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11-19-84 % MOIST - NO. 4 _____ DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL							
WT. PAN							
WET WT. RETAINED							_____ WET
DRY WT. RETAINED							_____ DRY
DRY WT. PASSING							
% OF TOTAL PASSING						100.0 = W_p	

SIEVE AND HYDROMETER ANALYSIS

DISH NO. X DRY WT. OF SAMPLE (W) = 100 gms. FACTOR (F) = $\frac{W_p}{W} = \frac{100.0}{100} =$ 1.000

DRY WT. OF SAMPLE (SIEVED) 27.8

SIEVING TIME 15 min DATE 11-24-84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	0	100.0		100.0	2.380	
16	0.1	99.9		99.9	1.190	
30	0.2	99.8		99.8	0.590	
50	1.2	98.8		98.8	0.297	
100	10.8	89.2		89.2	0.149	
200	27.8	72.2		72.2	0.074	
PAN	27.9					
TOTAL	27.9					

TESTED AND COMPUTED BY Jat CHECKED BY _____ DATE _____

HYDROMETER ANALYSIS

HYDROMETER NO. 25716 DISPERSING AGENT $(NaPO_3)_6$

STARTING TIME 9:02 AM DATE 11-22-84 AMOUNT 125 mL ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*		60+					0.050	Clear with lit.
1 MIN	17.0	55.0	5.7	49.3		47.3	0.037	Organic
4 MIN	17.0	41.5	5.7	35.8		35.8	0.019	
19 MIN	17.0	31.0	5.7	25.3		25.3	0.009	
60 MIN	17.0	28.5	5.4	23.1		23.1	0.005	
7 HR. 15 MIN*	20.0	20.5	4.8	15.7		15.7	0.002	
25 HR. 45 MIN*	20.0	17.0	4.8	12.2		12.2	0.001	

TESTED AND COMPUTED BY Jat CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 837-330

A-33

7-1391 (8-71)
Bureau of Reclamation

PROCTOR COMPACTION TEST

16.2

Pick-Sloan Missouri Basin Program — In Place Density CCDF-1

PROJECT Clark Canyon Dam FEATURE Drain Field D/S of Dam SAMPLE NO. CCDF-1

TESTED BY JAT COMPUTED BY JAT CHECKED BY [illegible] DATE Nov. '71

DEGREE OF COMPACTION, PROCTOR STANDARD ☒ OR MODIFIED ☐ IF MODIFIED, SHOW RELATED INFORMATION AS FOLLOWS:

BLOWS PER LAYER 25 NO. OF LAYERS 3 HEIGHT OF DROP 18

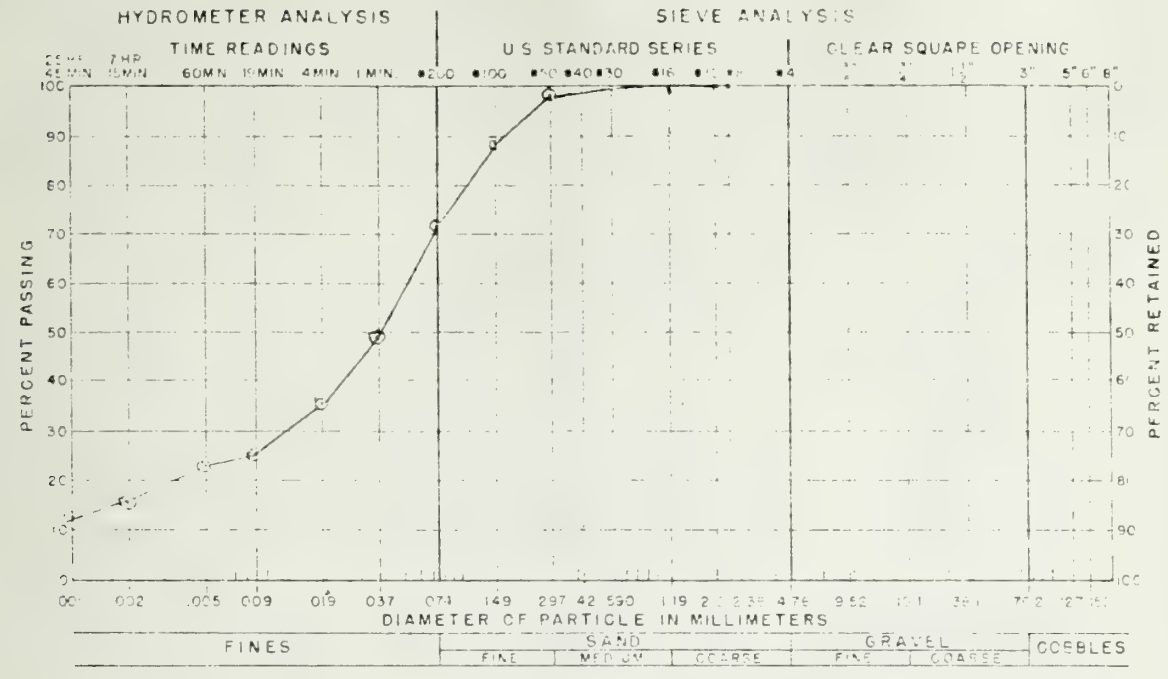
WEIGHT OF TAMPING ROD 5.5 lb VOLUME OF CYLINDER 0.0500 cc

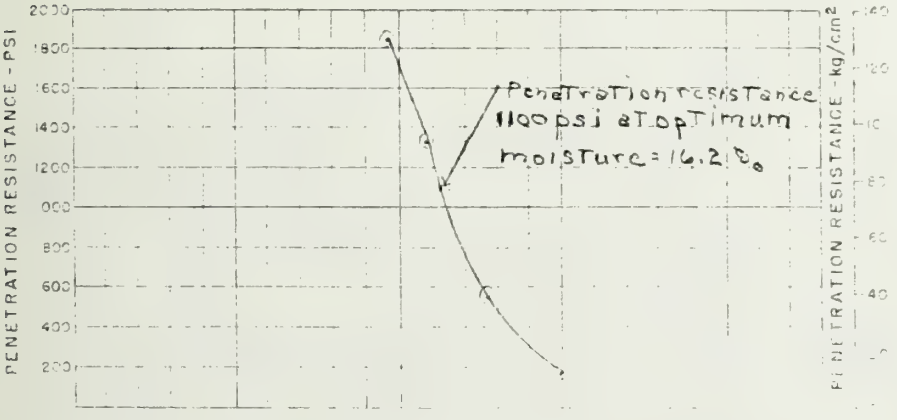
TEST NO.	1	2	3	4	5	6	7	8
DENSITY DETERMINATIONS								
WATER ADDED (cc)	-100 cc	-50 cc	-	50cc	100cc			
WT CYL.+ WET SOIL (lb).	12.91	13.23	13.31	13.37	13.23			
WT OF CYLINDER (lb)	7.08	7.08	7.08	7.08	7.08			
WT OF WET SOIL (lb)	5.83	6.15	6.23	6.31	6.15			
WT DENSITY (pcf)	116.6	123.0	124.6	126.2	123.0			
PENETRATION RESISTANCE DETERMINATIONS								
NEEDLE NO.	1/20	1/30	1/20	1/10	1/4			
AREA OF NEEDLE (sq in.)	1/20	1/30	1/20	1/10	1/4			
AVERAGE READING (lb)	74	61	67	55	44			
PENETRATION RESIST. (psi)	1480	1830	1340	550	176			
WATER CONTENT DETERMINATIONS								
DISH NO.	14	1	327	B	#9			
WT DISH + WET SOIL	652.2	641.0	700.5	512.9	778.1			
WT DISH + DRY SOIL	603.6	582.4	630.7	462.5	703.3			
WEIGHT OF DISH	210.0	183.8	186.5	176.1	228.7			
WEIGHT OF WATER	48.6	58.6	69.8	50.4	74.8			
WEIGHT OF DRY SOIL	385.6	398.6	444.2	286.4	474.6			
WATER CONT. IN PER CENT	12.6	14.7	15.7	17.6	20.0			
DRY DENSITY (pcf)	103.6	107.2	107.7	107.3	102.5			

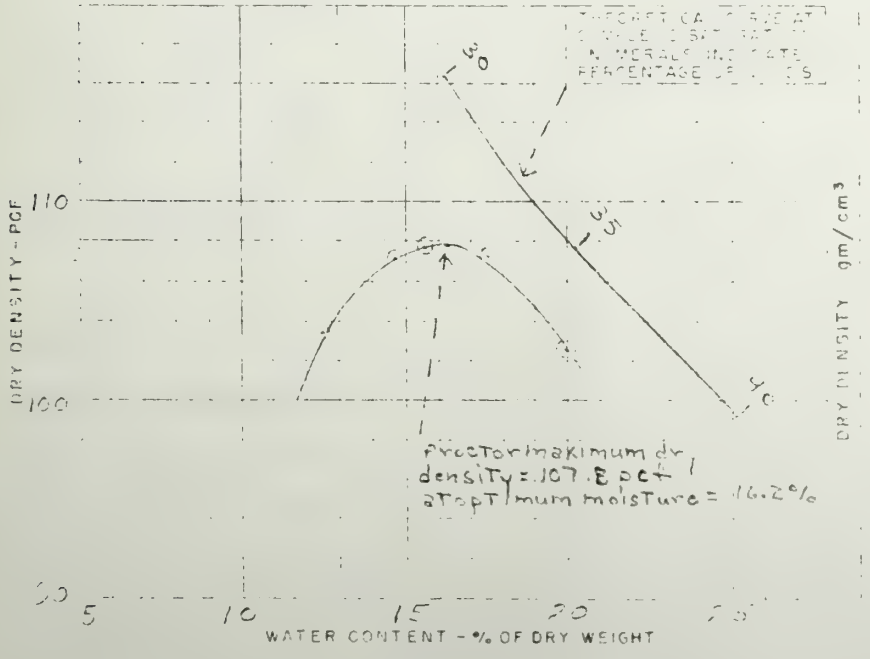
QUESTIONS TO ANSWER FROM OBSERVATIONS BY OPERATORS DURING TEST

1. HOW FAST DOES SAMPLE ABSORB WATER? FAST _____ MEDIUM ✓ SLOW _____
2. IS DIFFICULTY ENCOUNTERED IN MIXING WATER WITH SOIL? Some - balled up slightly on #4 pan
3. ARE PENETRATION NEEDLE READINGS RELIABLE? Yes
4. AT WHAT TEST NOS. IS SAMPLE CRUMBLY? 1 FIRM? 3 SOFT? 5
5. WAS BLEEDING NOTICED DURING TEST? No IF SO, WHAT TEST NOS.? _____
6. AT WHAT TEST NOS. IS SAMPLE SPONGY? 5 (slightly spongy on #5)
7. OTHER COMMENTS _____

PHYSICAL PROPERTIES SUMMARY PLOT (Compaction)






DRY DENSITY - PCF
DRY DENSITY gm/cm³
Proctor maximum dry density = 107.8 pcf at optimum moisture = 16.2%
WATER CONTENT - % OF DRY WEIGHT

CLASSIFICATION SYMBOL CL-ML

GRADATION SUMMARY

GRAVEL	0 %
SAND	27.8 %
FINES	72.2 %

ATTERBERG LIMITS

LIQUID LIMIT	27.3
PLASTICITY INDEX	6.5
SHRINKAGE LIMIT	%

SPECIFIC GRAVITY

MINUS NO. 4	2.66
PLUS NO. 4	
BULK	
APPARENT	
ABSORPTION	%

COMPACTION

% LARGER THAN TESTED
MAX. DRY DENSITY 107.8 PCF (gm/cm³)
OPTIMUM WATER CONT. 16.2 %
PENETRATION RESISTANCE PSI (kg/cm²)

PERMEABILITY SETTLEMENT

NOTES

COMPACTION – PENETRATION RESISTANCE CURVES

I.P.D. CCMF-1 DH84-13

SAMPLE NO. HOLE NO 10'D/S DEPTH 1.1' To 2.1' FT (m)

Figure

7-1702 (7-61)
Bureau of Reclamation

SOIL CONSISTENCY TEST
(ONE-POINT LIQUID LIMIT METHOD)

Sample No. CC-DF #1 IPD. Feature [illegible] Project ____

Air-dried ☒ Tested by [illegible] Date NOV. 19, 1969

Oven-dried ☐ Computed by [illegible] Date NOV. 21, 1969

Natural ☐ Checked by [illegible] Date ____

PLASTIC LIMIT

Trial No.	1	2
Dish No.	59	62
No. of blows (N)	—	—
Wt. Dish + Wet Soil	23.321	22.955
Wt. Dish + Dry Soil	21.571	21.208
Wt. Dish	13.182	12.767
Wt. Water	1.750	1.747
Wt. Dry Soil	8.389	8.441
% Moisture	20.86	20.70
Average Plastic Limit	20.8	

LIQUID LIMIT

	1	2
	H	
	32 / 22	
	17.729	
	13.726	
	5.883	
	4.003	
	10.843	
W_n =	27.72	
F_n =	1.985	
Liquid Limit	27.3	

$$LL = W_n \left(\frac{N}{25}\right)^{0.120}$$

$$F_n = \left(\frac{N}{25}\right)^{0.120}$$

$$LL = (F_n)\,(W_n)$$

N	F_n
20	0.974
21	0.979
(22)	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

SHRINKAGE LIMIT

1. Shrinkage Dish No.		
2. Wt. of Dish + Wet Soil		
3. Wt. of Dish + Dry Soil		
4. Wt. of Dish		
5. Wt. of Water (2-3)		
6. Wt. of Dry Soil (W_o)=(3-4)		
7. % Moisture (5/6 x 100)		
8. Vol. Shrinkage Dish (V)		
9. Vol. Dry Soil (V_o)		
10. $V - V_o$ = (8-9)		
11. $\frac{V - V_o}{W_o} \times 100 = \left(\frac{10}{6} \times 100\right)$		
12. Shrinkage Limit (7-11)		
13. Shrinkage Ratio (6/9)		

LIQUID LIMIT (LL) = 27.3

PLASTIC LIMIT (PL) = 20.8

PLASTICITY INDEX (PI) = [illegible]

SHRINKAGE LIMIT (SL) = ____

REMARKS

A-36

Form 7-1425(11-58)
Bureau of Reclamation

FIELD DENSITY TEST RECORD
(Including Rapid Compaction Control)

TEST NO. CC-DF-1 FEATURE Hot Canyon Dam TESTED BY GAT

LOCATION 10' N/S of DH84-13 OFFSET ELEV. 5513? ZONE COMPUTED BY GAT

SOURCE OF MATERIAL Imperial Density Test DATE OF TEST 11-2-84

(1)	Wt Sand & Can, No. 14	25.43	lbs.
(2)	Wt. Sand Residue & Can	20.59	lbs.
(3)	Wt. Sand used, [(1) - (2)]	4.84	lbs.
(4)	Wt. Sand in plate, No [illegible]	3.97	lbs
(5)	Wt. Sand in Hole, [(3) - (4)]	0.87	lbs
(6)	Sand Calibration	95.87	pcf.
(7)	Vol. of Hole, $\frac{(5)}{(6)}$	0.0132	ft³
(8)	Wt. Wet Soil, Rock, & Can	27.76	lbs.
(9)	Wt. of Can, No. 13	3.05	lbs.
(10)	Wt. Wet Soil & Rock (8)-(9)	24.71	lbs.
(11)	Wet Density Soil & Rock $\frac{(10)}{(7)}$	115.9	pcf.
(12)	Dry Density Soil & Rock, $\frac{(11)}{1+(28)}$	98.1	pcf
(13)	Wt Wet Rock[a] & Pan		lbs
(14)	Wt. of Pan		lbs.
(15)	Wt. Wet Rock,[a] [(13) - (14)]	None	lbs
(16)	Wt. Rock in Water		lbs
(17)	Volume of Rock[a] $\frac{(15)-(16)}{62.4}$ *		ft³
(18)	Sp. G of Rock,[a] $\frac{(15)}{[(15)-(16)]}$		
(19)	Wt Dry Rock & Pan		lbs
(20)	Wt Pan		lbs
(21)	Wt Oven Dry Rock [(19) - (20)]		lbs.
(22)	Rock Water Content, $\frac{[(15)-(21)]}{(21)} \times 100$		%
(23)	Wt. Wet Soil, [(10)-(15)]		lbs.
(24)	Wet Density of Soil, $\frac{(23)}{[(7)-(17)]}$		pcf.
(25)	Wt. Dry Soil, $\frac{(23)}{1+W_f}$		lbs.
(26)	Wt. Dry Soil & Rock, [(25)+(21)]		lbs.
(27)	Percentage of Rock, $\frac{(21)}{(26)} \times 100$		%
(28)	Water Content, Soil & Rock, $\frac{[(10)-(26)]}{(26)} \times 100$		%
(29)	Fill Cyl. Needle[b]		p.s.i.
(30)	Needle at opt.[b]		p.s.i.

RAPID CONTROL VALUES

(31)	D =		%
(32)	C =		%
(33)	$W_o - W_f$ =		%
(34)	Fill Water Content, W_f	18.1	%
(35)	Fill Dry Density,-No 4, $\frac{(24)}{1+W_f}$		p.c.f
(36)	Max Lab. Dry Density		p.c.f
(37)	Cylinder Dry Density		p.c.f.
(38)	Opt. Water Content, W_o		%

Method	Passes		
Tamping roller		Canal Lining	
Tractor treads		Embankment	
Equip. Tamp.		Str. B'kfill	
Power Tamp.		Unified Soil Class	
Hand Tamp			

REMARKS

* Or (17)$_A$ by measuring the water displaced from a siphon can, then:
(18)$_A$ = $\frac{(15)}{(17) \times 62.4}$

(a) Wet surface dried condition

U.S. Government Printing Office 1978

7-1452 (5-71)
Water and Power

MOISTURE DETERMINATIONS

PROJECT _____ FEATURE _____ LABORATORY INDEX NO. _____

SAMPLE NUMBER	CC-DF-#1 IPD.		CC-LF #2 IPD.					
DISH NUMBER	7		#1C					
WT DISH + WET SOIL	752.5		765.9					
WT DISH + DRY SOIL	654.5		694.0					
WEIGHT OF DISH	113.0		113.3					
WEIGHT OF WATER	98.0		71.9					
WEIGHT OF DRY SOIL	541.5		580.7					
PERCENT MOISTURE	18.1		12.4					
SAMPLE NUMBER								
DISH NUMBER								
WT DISH + WET SOIL								
WT DISH + DRY SOIL								
WEIGHT OF DISH								
WEIGHT OF WATER								
WEIGHT OF DRY SOIL								
PERCENT MOISTURE								
SAMPLE NUMBER								
DISH NUMBER								
WT DISH + WET SOIL								
WT DISH + DRY SOIL								
WEIGHT OF DISH								
WEIGHT OF WATER								
WEIGHT OF DRY SOIL								
PERCENT MOISTURE								

•U.S. Government Printing Office: 1981—777-006/1074

7-1589 (8-71)
Bureau of Reclamation

SPECIFIC GRAVITY TEST

PROJECT _____ FEATURE Clark Canyon Dam

DATE 11-19-84 TESTED BY BAS CHECKED BY HMM				
1. TRIAL	1		1	
2. SAMPLE NO.	CCDF-1		CCDF-2	
3. FLASK NO.	2		3	
4. TEMP °C, (Experimental)	21.2		20.7	
5. CHART WEIGHT AT TEMP (4) g.	468.85		467.33	
6. EXPERIMENTAL WEIGHT, (W) g.	431.4		430.0	
7 DISPLACED WATER, (5) - (6) g.	37.45		37.33	
8. (Dt) (100), FROM CHART TEMP (4) g.	99.7948		99.8056	
9. SPECIFIC GRAVITY (8) ÷ (7)	2.66		2.67	
10. AVERAGE SPECIFIC GRAVITY				

DATE _____ TESTED BY _____ CHECKED BY _____				
1. TRIAL				
2. SAMPLE NO.				
3. FLASK NO.				
4. TEMP °C, (Experimental)				
5. CHART WEIGHT AT TEMP (4) g.				
6. EXPERIMENTAL WEIGHT, (W) g.				
7. DISPLACED WATER, (5) - (6) g.				
8. (Dt) (100), FROM CHART TEMP (4) g.				
9. SPECIFIC GRAVITY (8) ÷ (7)				
10. AVERAGE SPECIFIC GRAVITY				

DATE _____ TESTED BY _____ CHECKED BY _____				
1. TRIAL				
2. SAMPLE NO.				
3. FLASK NO.				
4. TEMP °C, (Experimental)				
5. CHART WEIGHT AT TEMP (4) g.				
6. EXPERIMENTAL WEIGHT, (W) g.				
7. DISPLACED WATER, (5) - (6) g.				
8. (Dt) (100), FROM CHART TEMP (4) g.				
9. SPECIFIC GRAVITY, (8) ÷ (7)				
10. AVERAGE SPECIFIC GRAVITY				

* U. S. GPO: 1976—678-573/377 Region No.

7-1451 (8-71)
Bureau of Reclamation

SAMPLE PREPARATION AND GRADATION ANALYSIS

DH 84-13
I.P.D. 11½' D/S DH ~~8-11~~

LABORATORY SAMPLE NO. CCDF-2 11-5-84

FEATURE Clark Canyon Dam AREA _____ EXC. NO. CCDF-2 DEPTH 3.1' To 4.1'

SAMPLE PREPARATION

PREPARED BY BAS % MOIST + NO. 4 _____ WET WT. TOTAL SAMPLE _____

DATE 11-19-84 % MOIST - NO. 4 oven Dry DRY WT. TOTAL SAMPLE _____

SIEVE SIZE	5"	3"	1-1/2"	3/4"	3/8"	NO. 4	TOTAL WT. PASSING NO. 4
WT. PAN + RETAINED MATERIAL							
WT. PAN							
WET WT. RETAINED							_____ WET
DRY WT. RETAINED							_____ DRY
DRY WT. PASSING							
% OF TOTAL PASSING						100	- Wt.

SIEVE AND HYDROMETER ANALYSIS

DISH NO. 8 DRY WT. OF SAMPLE (W) = 100 gms. FACTOR (F) = $\frac{W_t}{W} = \frac{100.0}{100} =$ 1.000

DRY WT. OF SAMPLE (SIEVED) 39.9

SIEVING TIME 15 min. DATE 11-24-84

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	F X WEIGHT PASSING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
8	0	100.0		100.0	2.380	
16	0.1	99.9		99.9	1.190	
30	0.3	99.7		99.7	0.590	
50	2.3	97.7		97.7	0.297	
100	16.9	83.1		83.1	0.149	
200	39.9	60.1		60.1	0.074	
PAN	40.4					
TOTAL						

TESTED AND COMPUTED BY Cat CHECKED BY _____ DATE _____

HYDROMETER ANALYSIS

HYDROMETER NO. 25710 DISPERSING AGENT $(NaPO_3)_6$

STARTING TIME 8:48 AM DATE 11-22-84 AMOUNT 125 ml

TIME	TEMP C°	HYD READ	HYD CORR	CORR READ	F X CORRECT READ = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIA (mm)	REMARKS
.5 MIN*	17.0	56.0	5.7	50.3		50.3	0.050	Clear with 1.11
1 MIN	17.0	47.0	5.7	41.3		41.3	0.037	Organic
4 MIN	17.0	34.5	5.7	28.8		28.8	0.019	
19 MIN	17.0	23.5	5.7	17.8		17.8	0.009	
60 MIN	18.0	20.0	5.4	14.6		14.6	0.005	
7 HR. 15 MIN*	20.0	16.5	4.8	11.7		11.7	0.002	
25 HR. 45 MIN*	19.0	13.0	5.1	7.9		7.9	0.001	

TESTED AND COMPUTED BY Cat CHECKED BY _____ DATE _____

*Not required for standard test.

GPO 837-390

7-1391 (8-71)
Bureau of Reclamation

PROCTOR COMPACTION TEST

I.P.D. CCDF-2 ^
DH64-~~13~~ D/s of dam
Elev. 5511.2 (3.1 ft
Surf.

PROJECT Pick-Sloan Missouri Basin Program FEATURE Clark Canyon Dam SAMPLE NO. _____

TESTED BY Gat COMPUTED BY Gat CHECKED BY [illegible] DATE Nov. 2' 1[illegible]

DEGREE OF COMPACTION, PROCTOR STANDARD [X] OR MODIFIED [ ] IF MODIFIED, SHOW RELATED INFORMATION AS FOLLOWS:

BLOWS PER LAYER 25 NO. OF LAYERS 3 HEIGHT OF DROP 18

WEIGHT OF TAMPING ROD 5.5 lb VOLUME OF CYLINDER 0.0500 c

TEST NO.	1	2	3	4	5	6	7	8
DENSITY DETERMINATIONS								
WATER ADDED (cc)	—	+50cc	+100 cc	+150 cc	+200 cc	+250 cc	+300 cc	
WT CYL.+ WET SOIL (lb)	12.52	12.70	12.96	13.18	13.34	13.49	13.37	13.23
WT OF CYLINDER (lb)	7.08	7.08	7.08	7.08	7.08	7.08	7.08	7.08
WT OF WET SOIL (lb)	5.44	5.62	5.88	6.10	6.26	6.41	6.29	[illegible]
WT DENSITY (pcf)	108.8	112.4	117.6	122.0	125.2	128.2	125.8	[illegible]
PENETRATION RESISTANCE DETERMINATIONS								
NEEDLE NO.	30	30	30	30	30	20	[illegible]	¼
AREA OF NEEDLE (sq in.)	1/30	1/30	1/30	1/30	1/30	1/20	[illegible]	¼
AVERAGE READING (lb)	112	98	94	94	73	56	32	42
PENETRATION RESIST. (psi)	3360	2940	2820	2820	2190	1160	320	168
WATER CONTENT DETERMINATIONS								
DISH NO.	10	16	8	I	A	H	[illegible]	14
WT DISH + WET SOIL	610.9	685.0	588.3	565.2	585.6	712.1	749.1	794.
WT DISH + DRY SOIL	587.4	651.5	555.2	527.3	540.0	646.3	676.4	709.
WEIGHT OF DISH	218.2	219.4	197.9	180.8	176.0	185.1	217.0	218.
WEIGHT OF WATER	23.5	33.5	33.1	37.9	45.6	65.8	72.7	84.
WEIGHT OF DRY SOIL	369.2	432.1	357.3	346.5	364.0	461.2	457.4	47[illegible]
WATER CONT. (% DRY WT)	6.4	7.8	9.3	10.9	12.5	14.3	15.9	17.[illegible]
DRY DENSITY (pcf)	102.3	104.3	107.6	110.0	111.3	112.2	108.5	104.

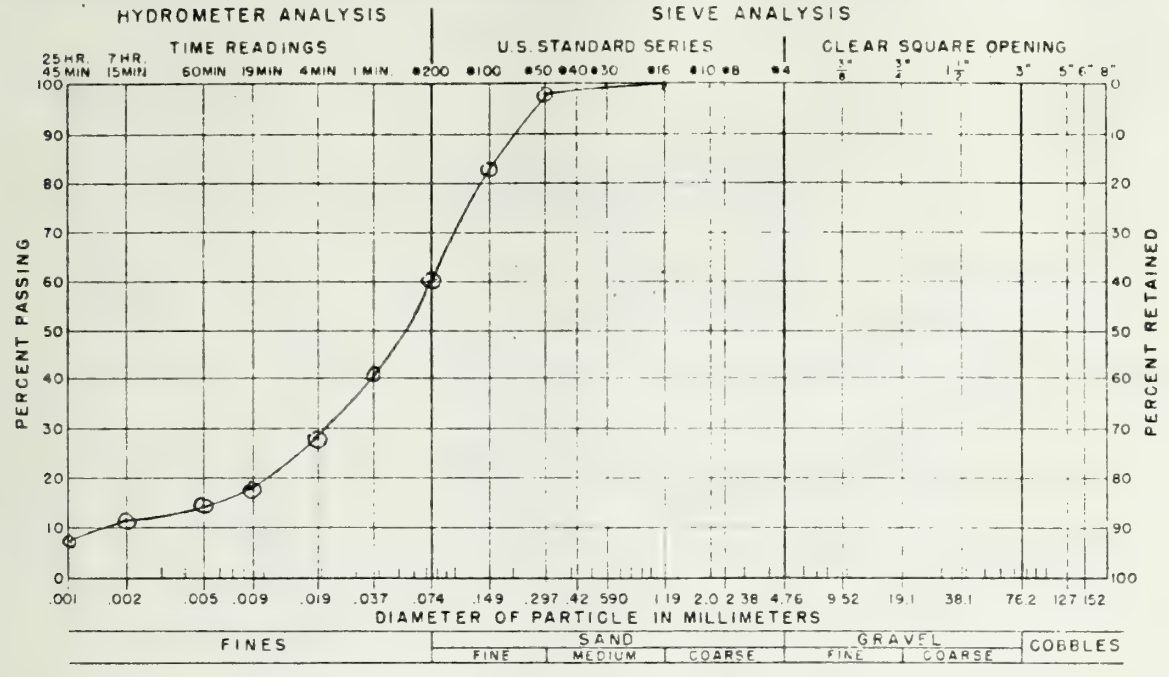
QUESTIONS TO ANSWER FROM OBSERVATIONS BY OPERATORS DURING TEST

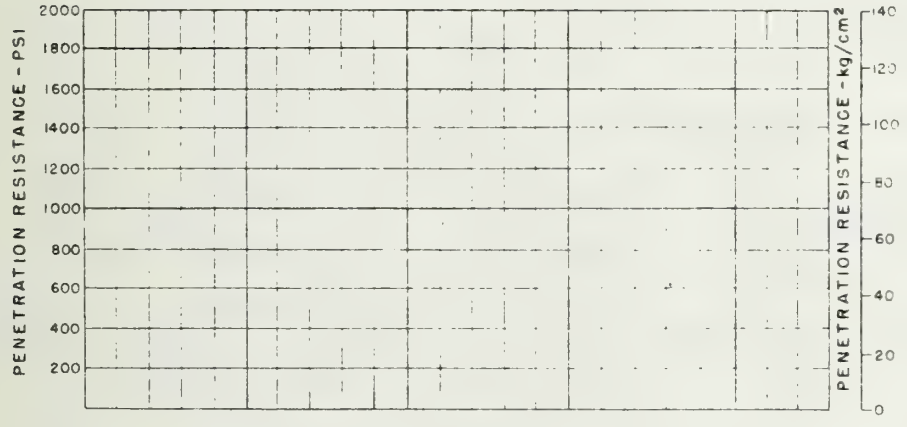
1. HOW FAST DOES SAMPLE ABSORB WATER? FAST ✓ MEDIUM _____ SLOW _____
2. IS DIFFICULTY ENCOUNTERED IN MIXING WATER WITH SOIL? yes
3. ARE PENETRATION NEEDLE READINGS RELIABLE? ? appear to be as no rock in sample but results are not what would be expected
4. AT WHAT TEST NOS. IS SAMPLE CRUMBLY? 1,2,3,4,5 FIRM? 6 SOFT? _____
5. WAS BLEEDING NOTICED DURING TEST? Yes IF SO, WHAT TEST NOS.? 7 & 8
6. AT WHAT TEST NOS. IS SAMPLE SPONGY? _____
7. OTHER COMMENTS Inplace density test below block sample 11½' D/s of I-8 1-1½

* U.S. Government Printing Office: 1976-677-348/1354 Re,

7-1565 (8-70)
Bureau of Reclamation

PHYSICAL PROPERTIES SUMMARY PLOT (Compaction)





CLASSIFICATION SYMBOL ML

GRADATION SUMMARY

GRAVEL	0 %
SAND	39.9 %
FINES	60.1 %

ATTERBERG LIMITS

LIQUID LIMIT	23.2 %
PLASTICITY INDEX	2.4
SHRINKAGE LIMIT	____ %

SPECIFIC GRAVITY

MINUS NO 4	2.67
PLUS NO 4	
BULK	
APPARENT	
ABSORPTION	____ %

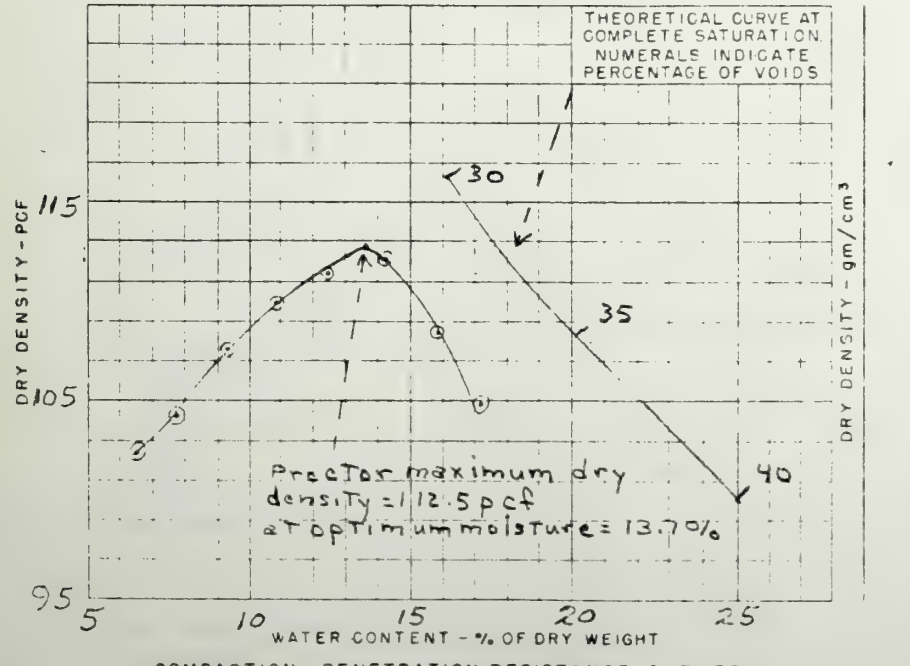
COMPACTION

% LARGER THAN TESTED ____
MAX DRY DENSITY 112.5 PCF
(____ gm/cm³)
OPTIMUM WATER CONT. 13.7 %
PENETRATION RESISTANCE ____ PSI
(____ kg/cm²)

PERMEABILITY SETTLEMENT

PLACEMENT CONDITION ____
COEF. OF PERMEABILITY ____ FT/YR
(____ cm/sec)
SETTLEMENT UNDER
____ PSI LOAD ____ %
(____ kg/cm²)

NOTES



COMPACTION - PENETRATION RESISTANCE CURVES

I.P.D. CCDF-2

SAMPLE NO. 11-5-84 HOLE NO. 11½' D/S of DEPTH 3.1' To 4.1' FT (____ m)

DH 84-~~14~~ 13

GPO 836-667

Figure

A-42

Form 7-1425(11-58)
Bureau of Reclamation

FIELD DENSITY TEST RECORD
(Including Rapid Compaction Control)

IPD
TEST NO. CC-DF-2 FEATURE Clark Canyon Dam TESTED BY Gat
11½' D/S 2H 84 ~~W~~ 3.1 ft below surface
LOCATION 13 OFFSET ELEV. 5511.9 ZONE COMPUTED BY Gat

SOURCE OF MATERIAL Inplace Density Test in Drain Field DATE OF TEST 11-5-84

(1)	Wt. Sand & Can, No. 4	45.00	lbs.
(2)	Wt. Sand Residue & Can	16.38	lbs.
(3)	Wt. Sand used, [(1) - (2)]	28.62	lbs.
(4)	Wt. Sand in plate, No. 2	3.97	lbs
(5)	Wt. Sand in Hole, [(3) - (4)]	24.65	lbs
(6)	Sand Calibration	95.87	pcf.
(7)	Vol. of Hole, $\frac{(5)}{(6)}$	0.2571	ft³
(8)	Wt. Wet Soil, Rock, & Can	30.07	lbs.
(9)	Wt. of Can, No. 17	3.05	lbs.
(10)	Wt. Wet Soil & Rock (8)-(9)	27.02	lbs.
(11)	Wet Density Soil & Rock $\frac{(10)}{(7)}$	105.1	pcf.
(12)	Dry Density Soil & Rock, $\frac{(11)}{1+(28)}$	93.5	pcf
(13)	Wt. Wet Rock° & Pan		lbs.
(14)	Wt. of Pan		lbs.
(15)	Wt. Wet Rock,° [(13) - (14)]	Trace	lbs.
(16)	Wt. Rock in Water		lbs.
(17)	Volume of Rock° $\frac{(15)-(16)}{62.4}$ *		ft³
(18)	Sp. G. of Rock,° $\frac{(15)}{[(15)-(16)]}$		
(19)	Wt Dry Rock & Pan		lbs
(20)	Wt Pan		lbs.
(21)	Wt Oven Dry Rock [(19) - (20)]		lbs.
(22)	Rock Water Content, $\frac{[(15)-(21)]}{(21)} \times 100$		%
(23)	Wt. Wet Soil, [(10)-(15)]		lbs.
(24)	Wet Density of Soil, $\frac{(23)}{[(7)-(17)]}$		pcf.
(25)	Wt. Dry Soil, $\frac{(23)}{1+W_f}$		lbs.
(26)	Wt. Dry Soil & Rock, [(25) + (21)]		lbs.
(27)	Percentage of Rock, $\frac{(21)}{(26)} \times 100$		%
(28)	Water Content, Soil & Rock, $\frac{[(10)-(26)]}{(26)} \times 100$		%
(29)	Fill Cyl. Needle[b]		p.s.i.
(30)	Needle at opt.[b]		p.s.i.

RAPID CONTROL VALUES

(31)	D=	%
(32)	C=	%
(33)	$w_o - w_f$ =	%
(34)	Fill Water Content, w_f	12.4 %
(35)	Fill Dry Density,-No 4, $\frac{(24)}{1+W_f}$	p.c.f.
(36)	Max. Lab. Dry Density	p.c.f
(37)	Cylinder Dry Density	p.c.f.
(38)	Opt. Water Content, w_o	%

Method	Passes		
Tamping roller		Canal Lining	
Tractor treads		Embankment	
Equip. Tamp.		Str. B'kfill	
Power Tamp.		Unified Soil Class	
Hand Tamp.			

REMARKS Max size 1"

* Or (17)$_A$ by measuring the water displaced from a siphon can; then
(18)$_A = \frac{(15)}{(17) \times 62.4}$

(a) Wet surface dried condition

(b) If obtained for moisture content by needle moisture test

U S Government Printing Office: 1978 677-078/1215

7-1702 (7-61)
Bureau of Reclamation

SOIL CONSISTENCY TEST
(ONE-POINT LIQUID LIMIT METHOD)

Sample No. CC-DF #2 IPD — Feature Clark Canyon Dam MT — Project _____

Air-dried ☒ — Tested by _____ — Date NOV. 19, 198_

Oven-dried ☐ — Computed by _____ — Date NOV. 21, 198_

Natural ☐ — Checked by _____ — Date _____

PLASTIC LIMIT

Trial No.	1	2
Dish No.	60	76
No. of blows (N)	—	—
Wt. Dish + Wet Soil	20.127	20.912
Wt. Dish + Dry Soil	18.885	19.500
Wt. Dish	12.891	12.770
Wt. Water	1.242	1.412
Wt. Dry Soil	5.994	6.730
% Moisture	20.72	20.98
Average Plastic Limit	20.8	

LIQUID LIMIT

	1	2
	8	
	23 | 24	
	19.391	
	16.455	
	3.680	
	2.936	
	12.575	
W_n =	23.35	
F_n =	0.995	
Liquid Limit	23.2	

$$LL = W_n \left(\frac{N}{25}\right)^{0.120}$$

$$F_n = \left(\frac{N}{25}\right)^{0.120}$$

$$LL = (F_n)(W_n)$$

N	F_n
20	0.974
21	0.979
22	0.985
23	0.990
(24)	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

SHRINKAGE LIMIT

1. Shrinkage Dish No.		
2. Wt. of Dish + Wet Soil		
3. Wt. of Dish + Dry Soil		
4. Wt. of Dish		
5. Wt. of Water (2-3)		
6. Wt. of Dry Soil (W_o)=(3-4)		
7. % Moisture (5/6 x 100)		
8. Vol. Shrinkage Dish (V)		
9. Vol. Dry Soil (V_o)		
10. $V-V_o$ = (8-9)		
11. $\frac{V-V_o}{W_o} \times 100 = \left(\frac{10}{6} \times 100\right)$		
12. Shrinkage Limit (7-11)		
13. Shrinkage Ratio (6/9)		

LIQUID LIMIT (LL) = 23.2

PLASTIC LIMIT (PL) = 20.8

PLASTICITY INDEX (PI) = 2.4

SHRINKAGE LIMIT (SL) = _____

REMARKS

GFO 647-169

7-1589 (8-71)
Bureau of Reclamation

SPECIFIC GRAVITY TEST

PROJECT _____ FEATURE Clark Canyon Dam

DATE 11-19-84 TESTED BY BAS CHECKED BY [illegible]				
1. TRIAL	1		1	
2. SAMPLE NO.	CCDF-1		CCDF-2	
3. FLASK NO.	2		3	
4. TEMP °C, (Experimental)	21.2		20.7	
5. CHART WEIGHT AT TEMP (4) g.	468.85		467.33	
6. EXPERIMENTAL WEIGHT, (W) g.	431.4		430.0	
7 DISPLACED WATER, (5) - (6) g.	37.45		37.33	
8. (Dt) (100), FROM CHART TEMP (4) g.	99.7948		99.8056	
9. SPECIFIC GRAVITY (8) ÷ (7)	2.66		2.67	
10. AVERAGE SPECIFIC GRAVITY				

DATE _____ TESTED BY _____ CHECKED BY _____				
1. TRIAL				
2. SAMPLE NO.				
3. FLASK NO.				
4. TEMP °C, (Experimental)				
5. CHART WEIGHT AT TEMP (4) g.				
6. EXPERIMENTAL WEIGHT, (W) g.				
7. DISPLACED WATER, (5) - (6) g.				
8. (Dt) (100), FROM CHART TEMP (4) g.				
9. SPECIFIC GRAVITY (8) ÷ (7)				
10. AVERAGE SPECIFIC GRAVITY				

DATE _____ TESTED BY _____ CHECKED BY _____				
1. TRIAL				
2. SAMPLE NO.				
3. FLASK NO.				
4. TEMP °C, (Experimental)				
5. CHART WEIGHT AT TEMP (4) g.				
6. EXPERIMENTAL WEIGHT, (W) g.				
7. DISPLACED WATER, (5) - (6) g.				
8. (Dt) (100), FROM CHART TEMP (4) g.				
9. SPECIFIC GRAVITY, (8) ÷ (7)				
10. AVERAGE SPECIFIC GRAVITY				

* U. S. GPO: 1976—678-673/377 Rev.

9-1452 (8-71)
Water and Power

MOISTURE DETERMINATIONS

PROJECT _____ FEATURE _____ LABORATORY INDEX NO. _____

SAMPLE NUMBER	CC-DF-#1 IPD.		CC-DF #2 IPD.					
DISH NUMBER	7		#10					
WT DISH + WET SOIL	752.5		765.9					
WT DISH + DRY SOIL	654.5		694.0					
WEIGHT OF DISH	113.0		113.3					
WEIGHT OF WATER	98.0		71.9					
WEIGHT OF DRY SOIL	541.5		580.7					
PERCENT MOISTURE	18.1		12.4					
SAMPLE NUMBER								
DISH NUMBER								
WT DISH + WET SOIL								
WT DISH + DRY SOIL								
WEIGHT OF DISH								
WEIGHT OF WATER								
WEIGHT OF DRY SOIL								
PERCENT MOISTURE								
SAMPLE NUMBER								
DISH NUMBER								
WT DISH + WET SOIL								
WT DISH + DRY SOIL								
WEIGHT OF DISH								
WEIGHT OF WATER								
WEIGHT OF DRY SOIL								
PERCENT MOISTURE								

*U.S. Government Printing Office : 1981—777-006/1071

Northern

Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: Surface Samples

Classification _____

Sample No. 140346

Job No. 61-114

Date July 1964

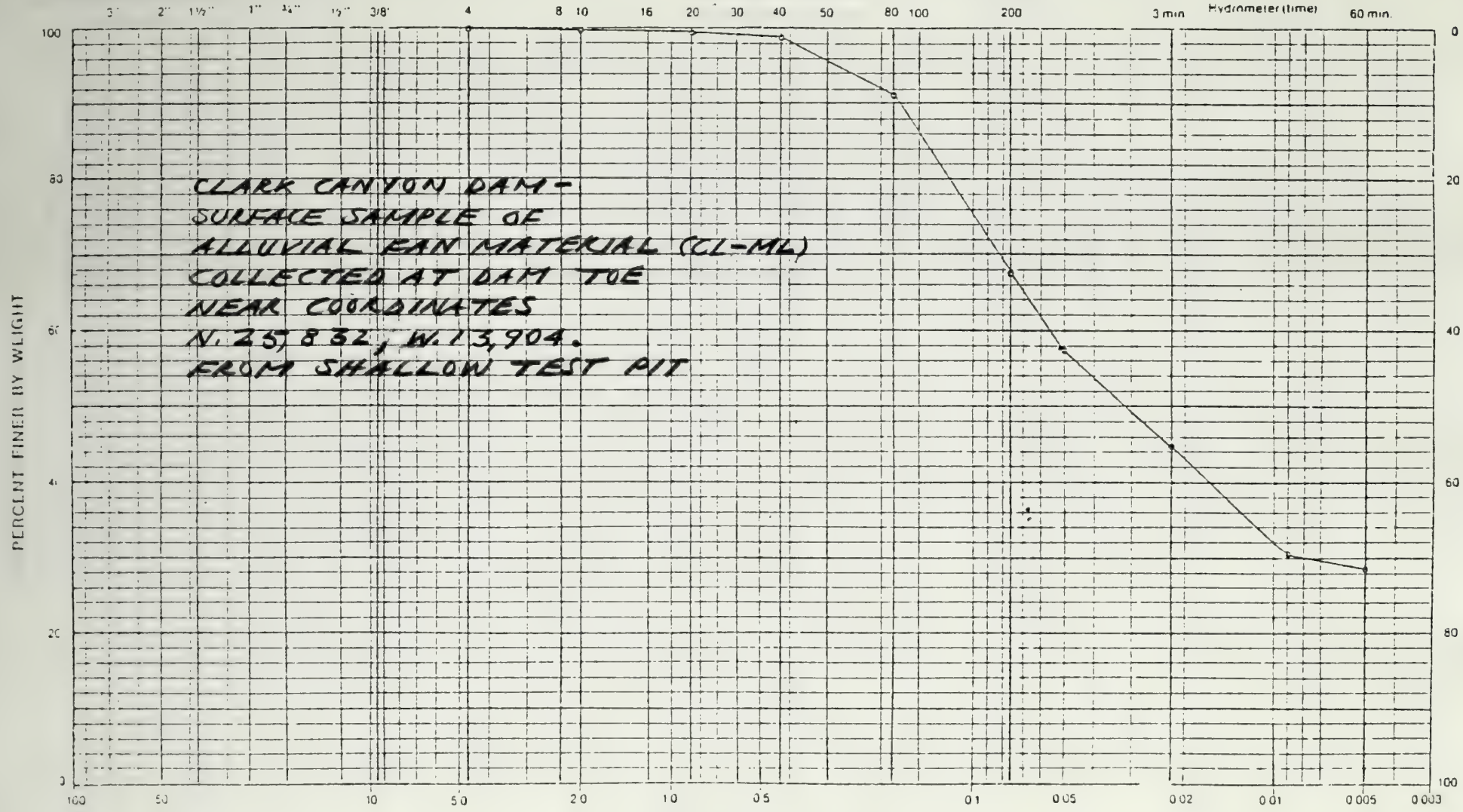
Moisture Content _____ %

Liquid Limit _____ %

Plasticity Index _____ %

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U.S. Standard Sieve Opening in Inches
3" 2" 1½" 1" ¾" ½" 3/8"
U.S. Standard Sieve Numbers
4 8 10 16 20 30 40 50 80 100 200
3 min
Hydrometer (time)
60 min.
CLARK CANYON DAM -
SURFACE SAMPLE OF
ALLUVIAL FAN MATERIAL (CL-ML)
COLLECTED AT DAM TOE
NEAR COORDINATES
N. 25,832, W. 13,904.
FROM SHALLOW TEST PIT
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
GRAIN SIZE IN MILLIMETERS
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

A-96

* RIGHT ABUTMENT DRAIN STATION (NOT DAM)

Northern Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: * Station 9+70 Zone 2

Classification _____

Sample No. 141333

Job No. 61-114

Date 9/26/84

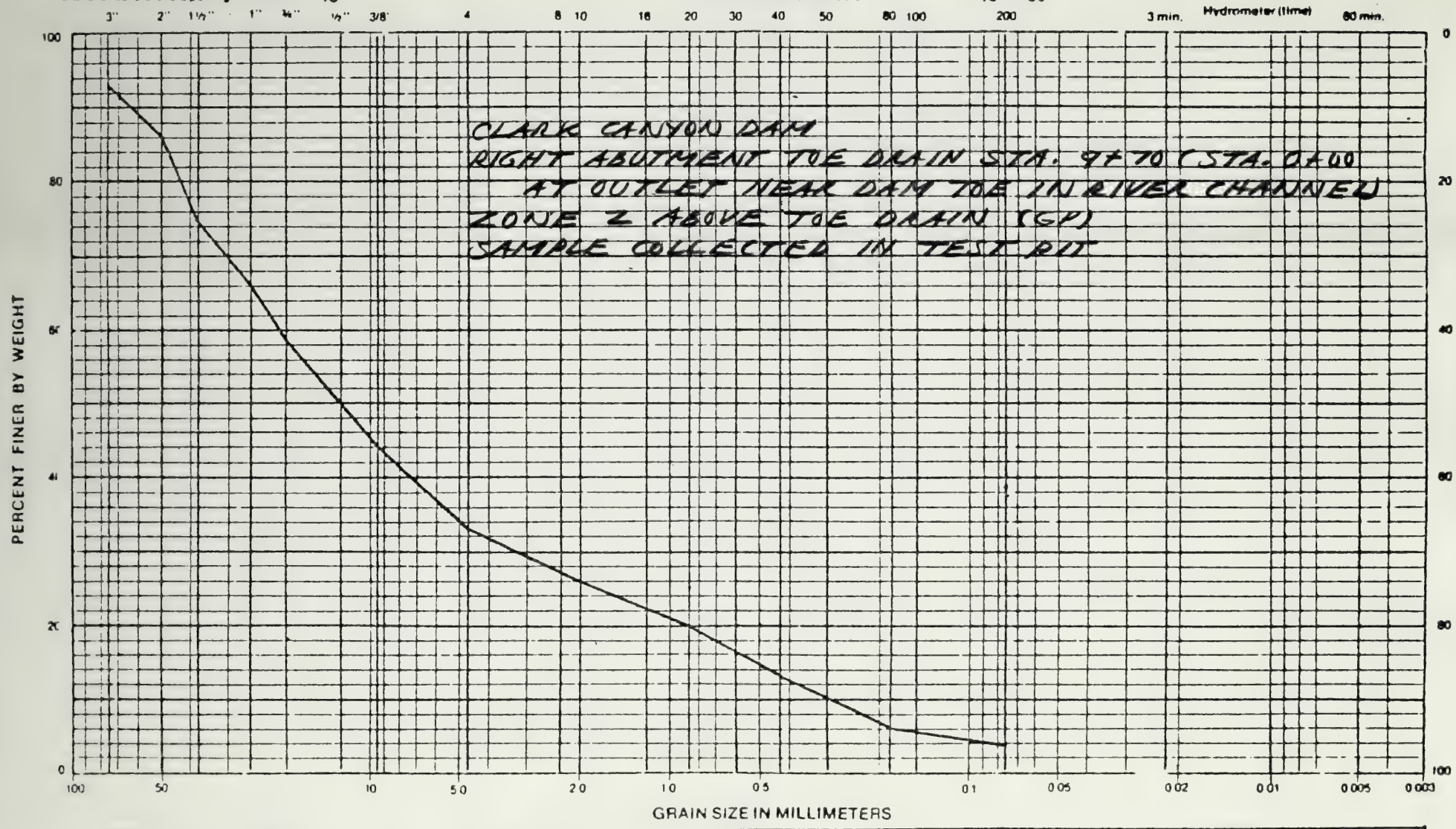
Moisture Content _____ %

Liquid Limit _____ %

Plasticity Index _____ %

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U.S. Standard Sieve Opening in Inches
3" 2" 1½" 1" ¾" ½" 3/8"
U.S. Standard Sieve Numbers
4 8 10 16 20 30 40 50 80 100 200
Hydrometer (time)
3 min. 60 min.
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
0 20 40 60 80 100
CLARK CANYON DAM
RIGHT ABUTMENT TOE DRAIN STA. 9+70 (STA. 0+00 AT OUTLET NEAR DAM TOE IN RIVER CHANNEL)
ZONE 2 ABOVE TOE DRAIN (GP)
SAMPLE COLLECTED IN TEST PIT
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003
GRAIN SIZE IN MILLIMETERS

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

* RIGHT ABUTMENT DRAIN STATION (NOT DAM)

Northern Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: * Station 9+70 Sand Around Drain

Classification _____

Sample No. 141335

Job No. 61-114

Date 9/26/84

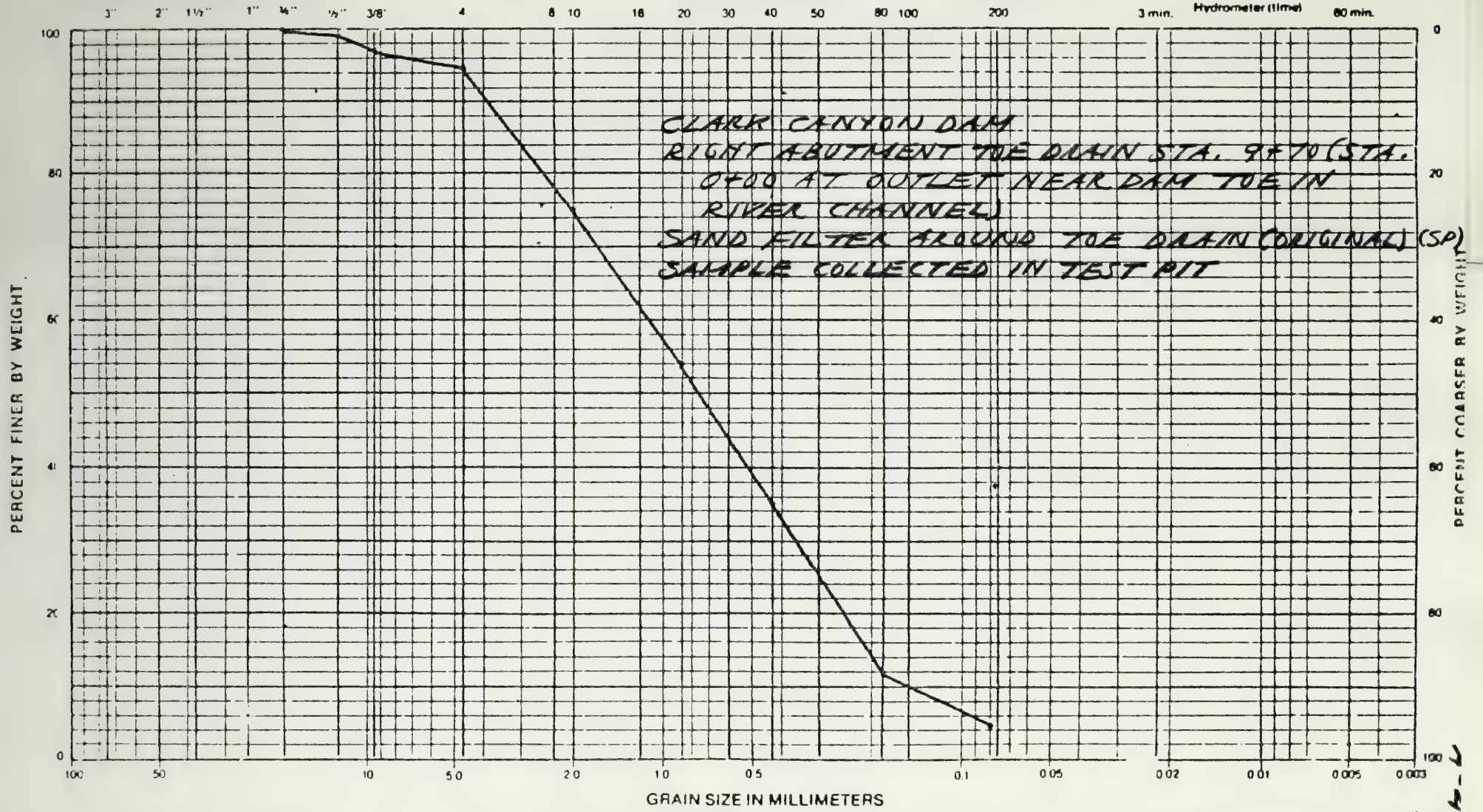
Moisture Content _____ %

Liquid Limit _____ %

Plasticity Index _____ %

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U S Standard Sieve Opening in Inches
3" 2" 1½" 1" ¾" ½" 3/8" 4 8 10 16 20 30 40 50 80 100 200
U S Standard Sieve Numbers
3 min. Hydrometer (time) 60 min.
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003
GRAIN SIZE IN MILLIMETERS
CLARK CANYON DAM
RIGHT ABUTMENT TOE DRAIN STA. 9+70 (STA. 0+00 AT OUTLET NEAR DAM TOE IN RIVER CHANNEL)
SAND FILTER AROUND TOE DRAIN (ORIGINAL) (SP)
SAMPLE COLLECTED IN TEST PIT

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

7-9

* RIGHT ABUTMENT DRAIN STATION (NOT DAM)

Northern Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: * Station 9+70 Gravel Around Drain

Classification _____

Sample No. 141334

Job No. 61-114

Date 9/26/84

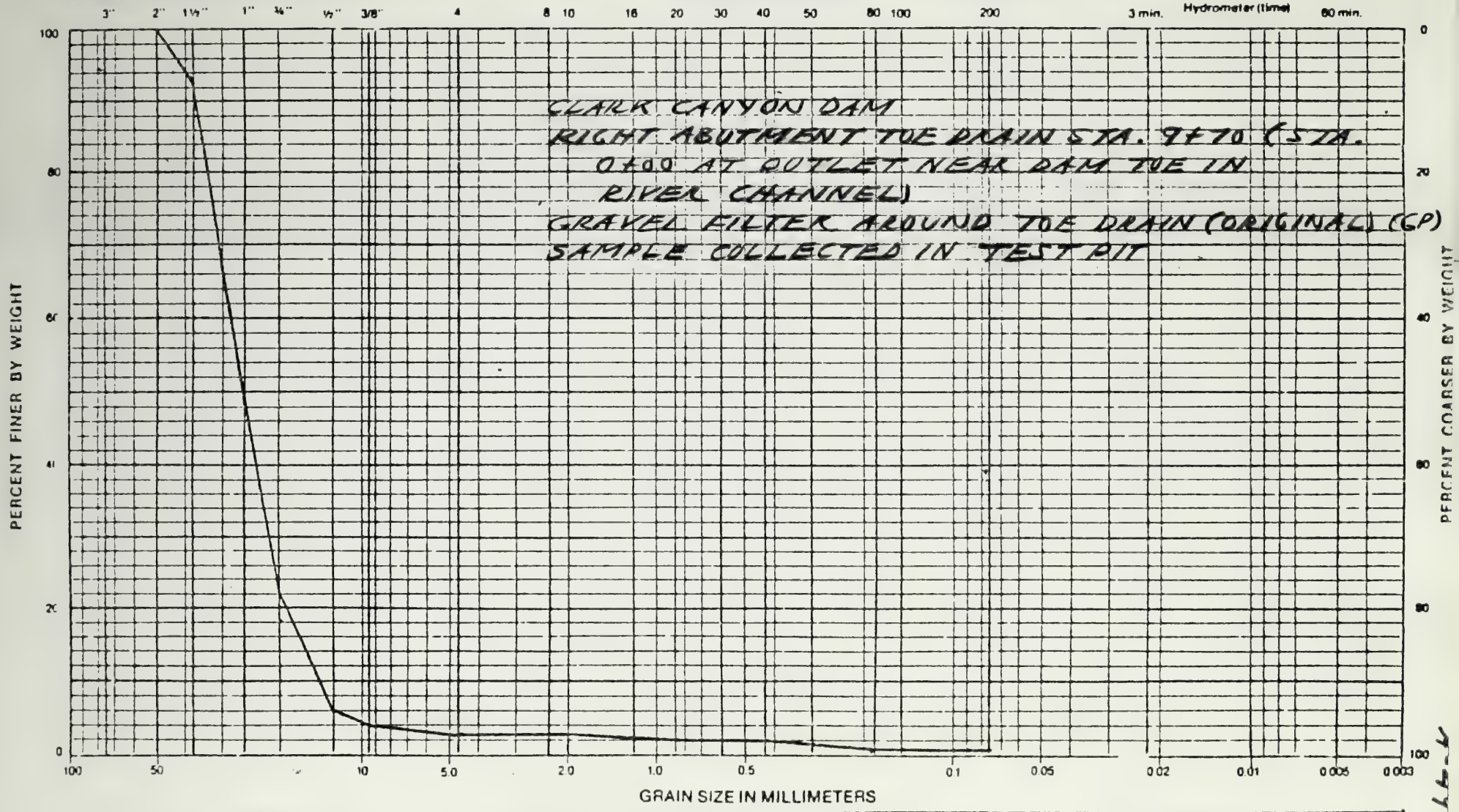
Moisture Content _____%

Liquid Limit _____%

Plasticity Index _____%

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U.S. Standard Sieve Opening in Inches
3" 2" 1½" 1" ¾" ½" 3/8"
U.S. Standard Sieve Numbers
4 8 10 16 20 30 40 50 80 100 200
Hydrometer (time)
3 min. 60 min.
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
GRAIN SIZE IN MILLIMETERS
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003
CLARK CANYON DAM
RIGHT ABUTMENT TOE DRAIN STA. 9+70 (STA. 0+00 AT OUTLET NEAR DAM TOE IN RIVER CHANNEL)
GRAVEL FILTER AROUND TOE DRAIN (ORIGINAL) (CP)
SAMPLE COLLECTED IN TEST PIT

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

* RIGHT ABUTMENT DRAIN STATION (NOT DAM)

Northern Engineering and Testing, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Clark Canyon Dam

Location: * Station 7+20 Drain Foundation
ALLUVIAL FAN

Classification _____

Sample No. 141337

Job No. 61-114

Date 9/26/84

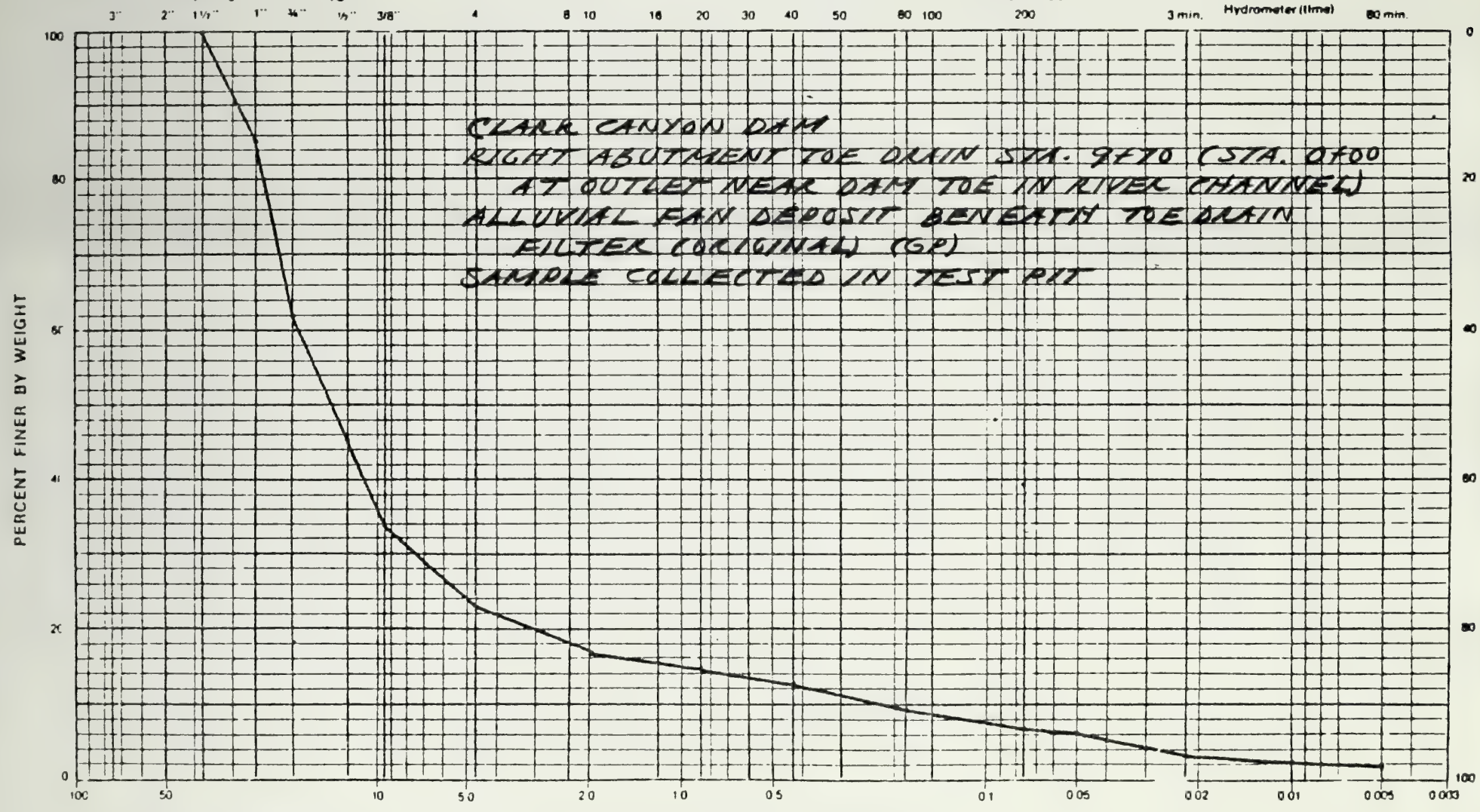
Moisture Content _____ %

Liquid Limit _____ %

Plasticity Index _____ %

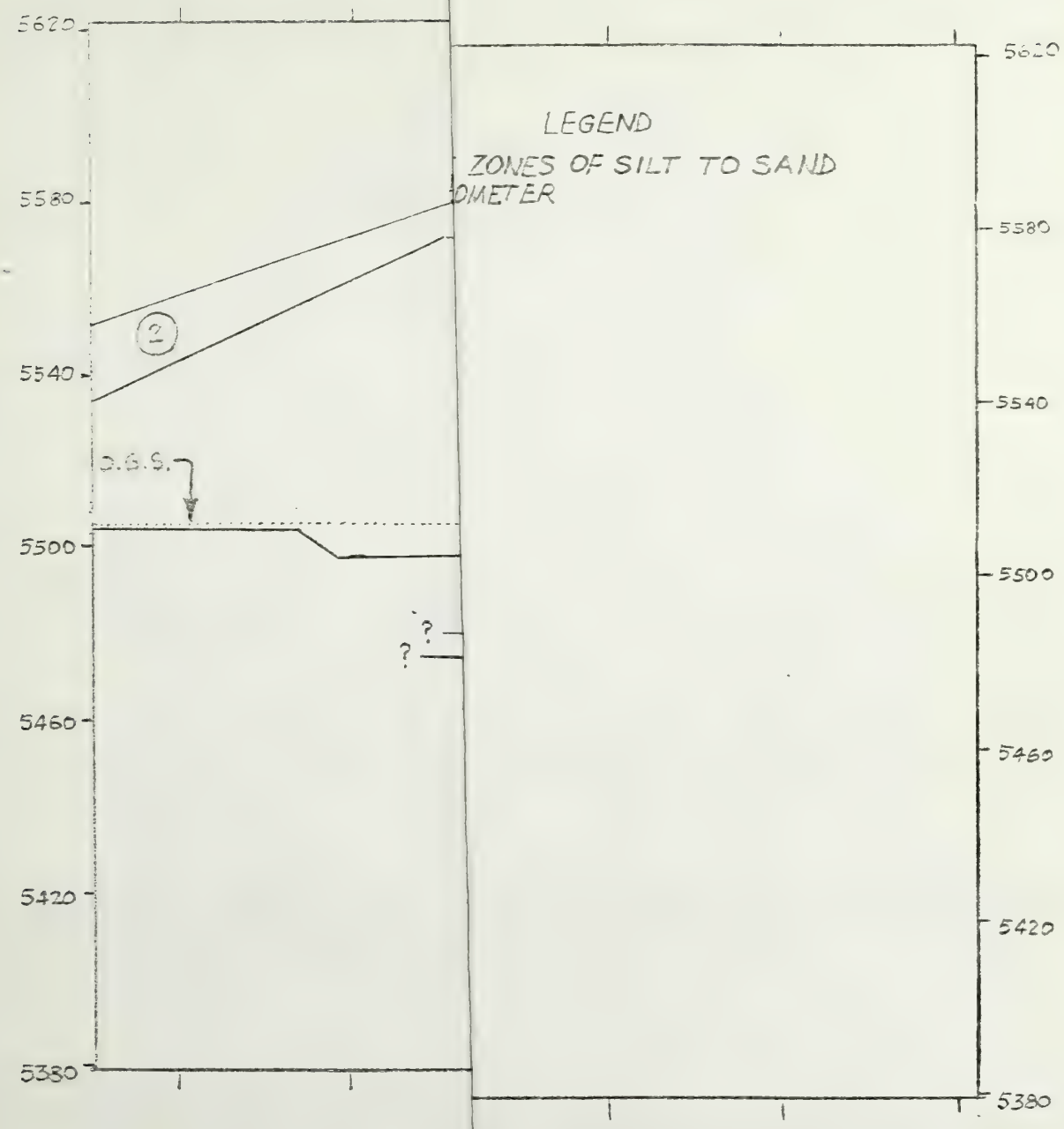
Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = _____

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = _____


U.S. Standard Sieve Opening in Inches
3" 2" 1½" 1" ¾" ½" 3/8"
U.S. Standard Sieve Numbers
4 8 10 16 20 30 40 50 80 100 200
3 min. Hydrometer (time) 60 min.
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
100 80 60 40 20 0
CLARK CANYON DAM
RIGHT ABUTMENT TOE DRAIN STA. 9+70 (STA. 0+00 AT OUTLET NEAR DAM TOE IN RIVER CHANNEL)
ALLUVIAL FAN DEPOSIT BENEATH TOE DRAIN
FILTER (ORIGINAL) (GP)
SAMPLE COLLECTED IN TEST PIT
100 50 10 5.0 2.0 1.0 0.5 0.1 0.05 0.02 0.01 0.005 0.003
GRAIN SIZE IN MILLIMETERS

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

FIGURE 2



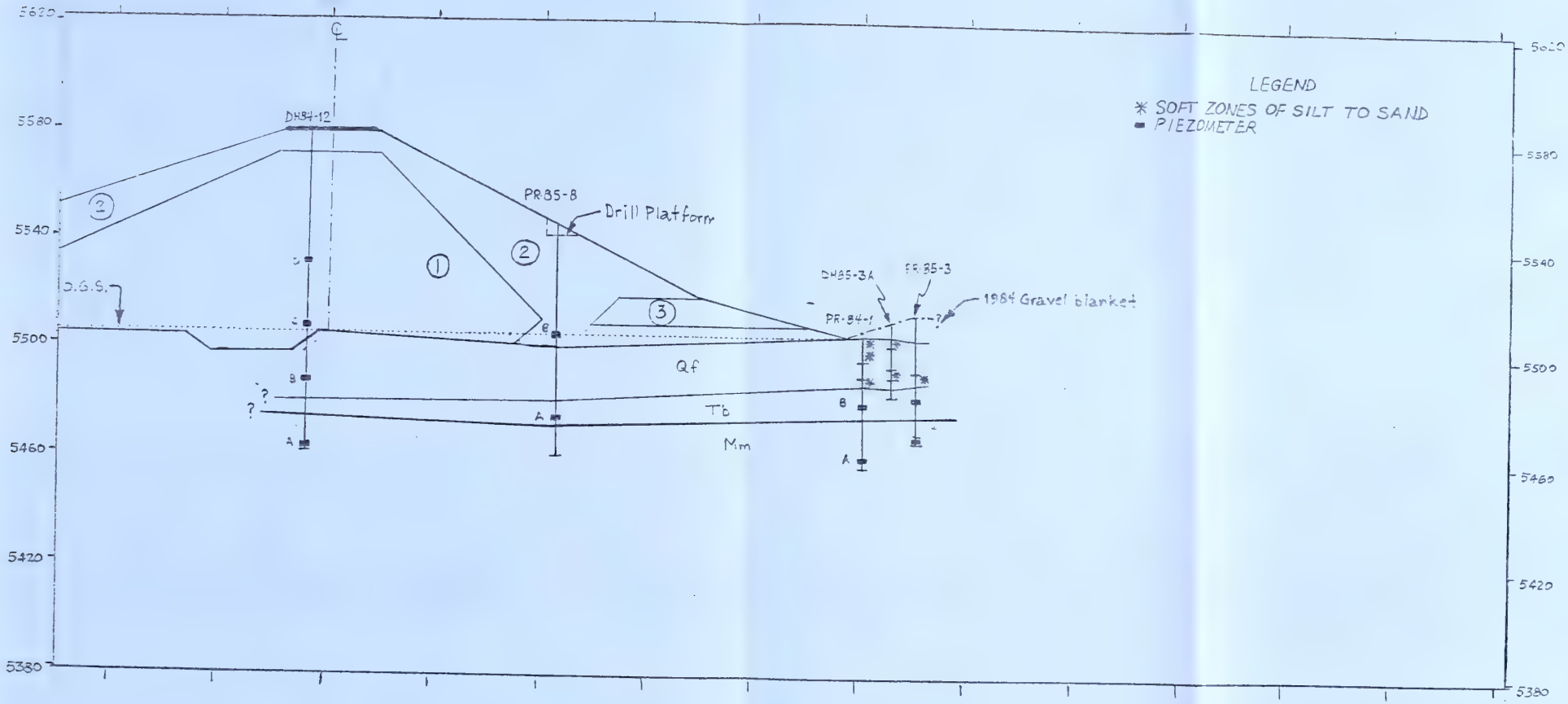
EXPLANATIONS

(1) Selected clay, silt, sand
by tamping rollers to
(2) Selected sand, gravel ar
crawler type tractor f
(3) Miscellaneous material c
tractor to 12 inch lay
(4) Qf = Alluvial fan deposit;
Mm = Madison Limest

CLARK CANYON DAM
SECTION 1-1
STATION 17+00

0 40 80
SCALE IN FEET

FIGURE 2



EXPLANATIONS

(1) Selected clay, silt, sand and gravel compacted by tamping rollers to 6 inch layers.
(2) Selected sand, gravel and cobbles compacted by crawler type tractor to 8 inch layers.
(3) Miscellaneous material compacted by crawler type tractor to 12 inch layers.
(4) Qf = Alluvial fan deposit; Tb = Beaverhead Conglomerate; Mm = Madison Limestone.

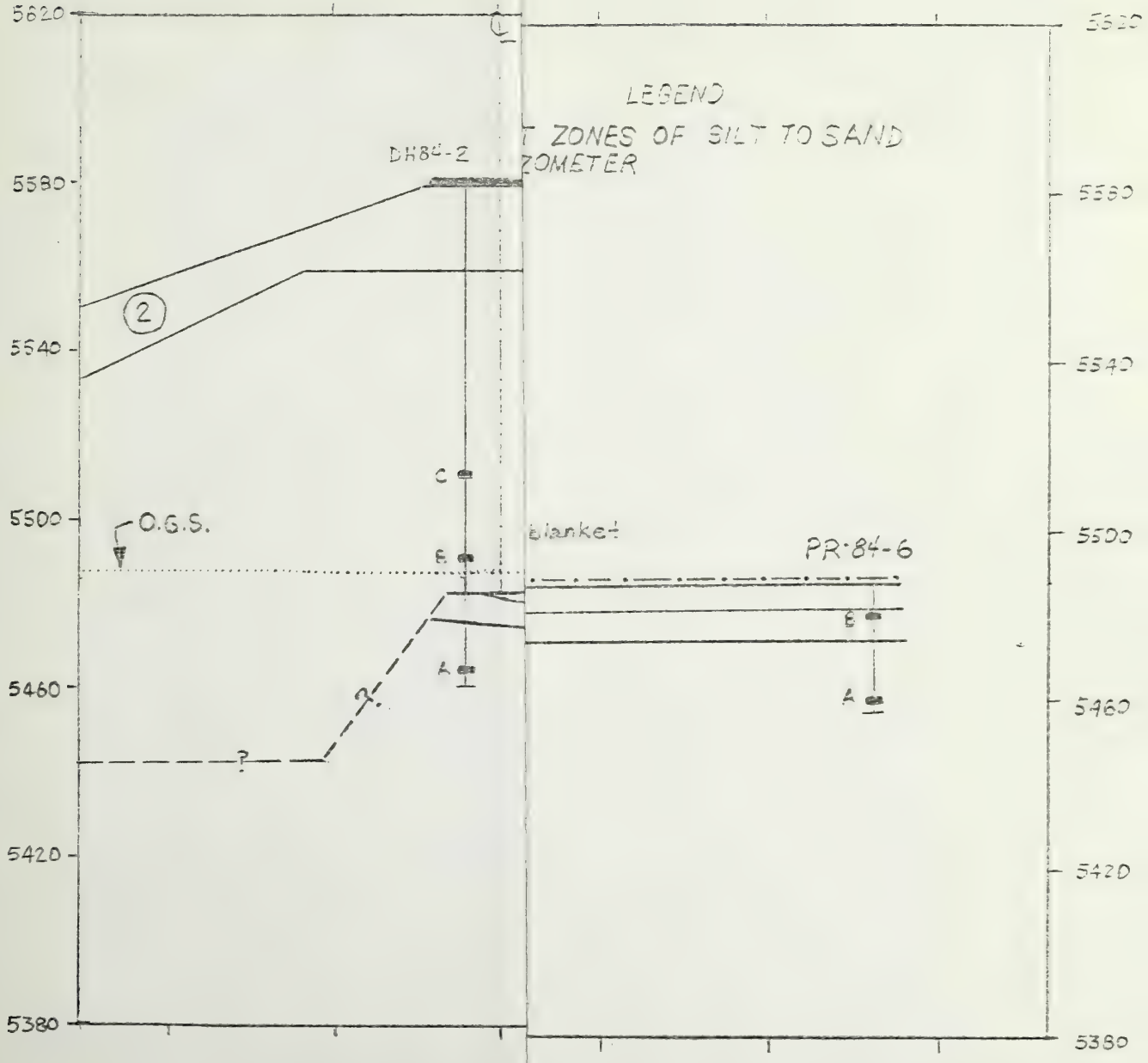
NOTES

1. O.G.S. (ORIGINAL GROUND SURFACE) from drawing number 699-D-246.
2. Core trench excavation from drawing number 699-D-196.
3. Embankment zoning from drawing number 699-D-197.
4. Notes 2 and 3 modified by drilling.

CLARK CANYON DAM
SECTION 1-1
STATION 17+00

0 40 80
SCALE IN FEET

FIGURE 3



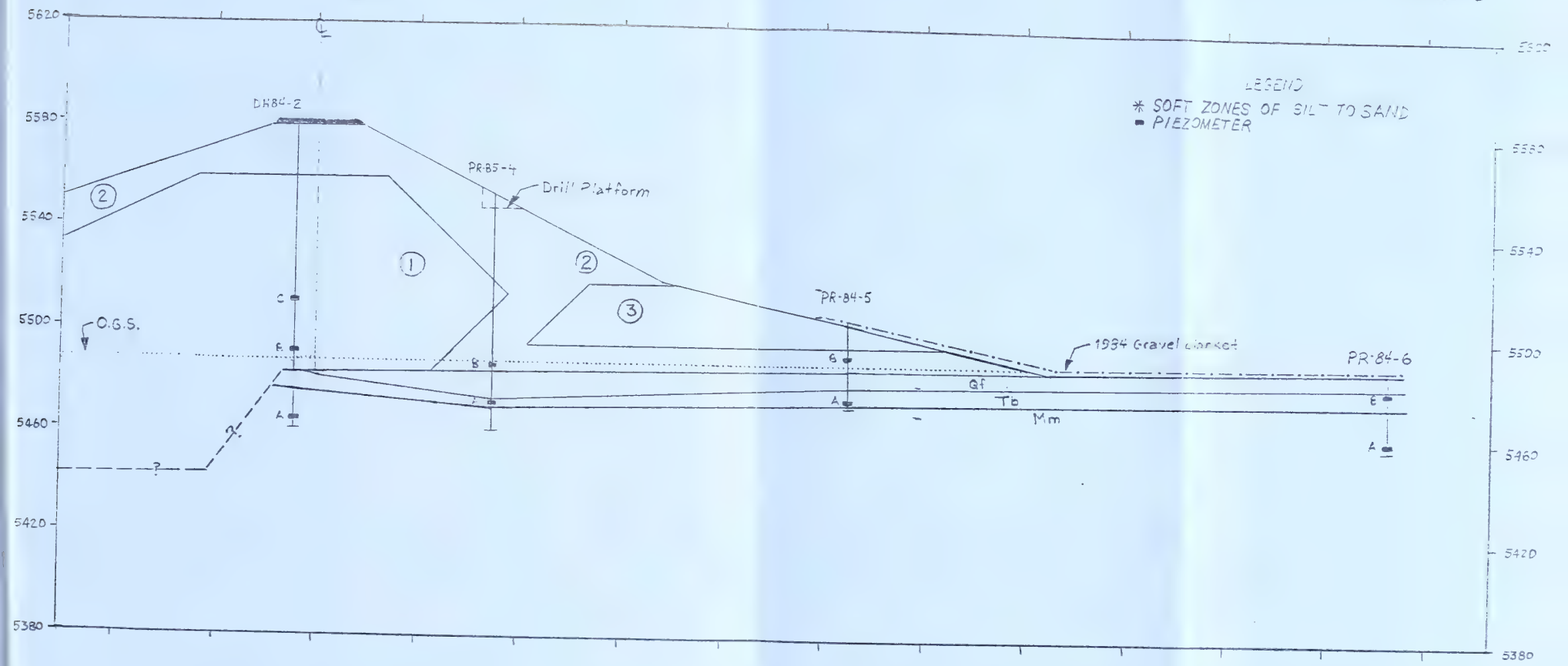
EXPLANATIONS

(1) Selected clay, silt, sand and
by tamping rollers to 6 inc
(2) Selected sand, gravel and co
crawler type tractor to 8
(3) Miscellaneous material compac
tractor to 12 inch layers.
(4) Qf = Alluvial fandeposit; Tb =
Mm = Madison Limestone.

CLARK CANYON DAM
SECTION 2-2
STATION 19+00

0 40 80
SCALE IN FEET

FIGURE 3



EXPLANATIONS

(1) Selected clay, silt, sand and gravel compacted by tamping rollers to 6 inch layers.
(2) Selected sand, gravel and cobbles compacted by crawler type tractor to 8 inch layers.
(3) Miscellaneous material compacted by crawler type tractor to 12 inch layers.
(4) Qf = Alluvial fan deposit; Tb = Beaverhead Conglomerate; Mm = Madison Limestone.

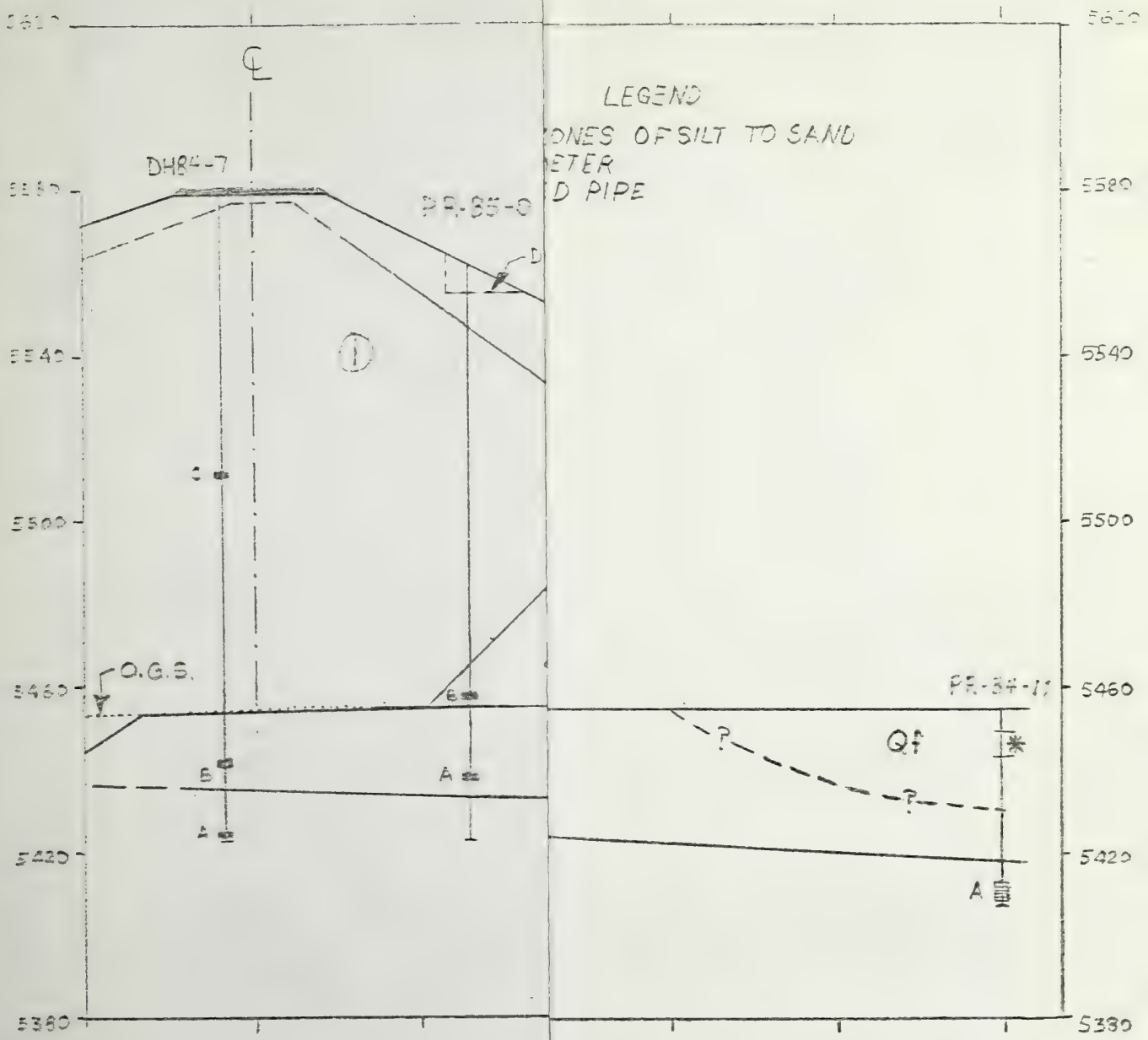
NOTES

1. O.G.S. (ORIGINAL GROUND SURFACE) from drawing number 699-D-246.
2. Core trench excavation from drawing number 699-D-196.
3. Embankment zoning from drawing number 699-D-197.
4. Notes 2 and 3 modified by drilling.

CLARK CANYON DAM
SECTION 2-2
STATION 19+00

0 40 80
SCALE IN FEET

FIGURE 11



EXPLANATIONS

UYON DAM

(1) Selected clay, silt, sand and gr 3-3
by tamping rollers to 6 inch 24+50

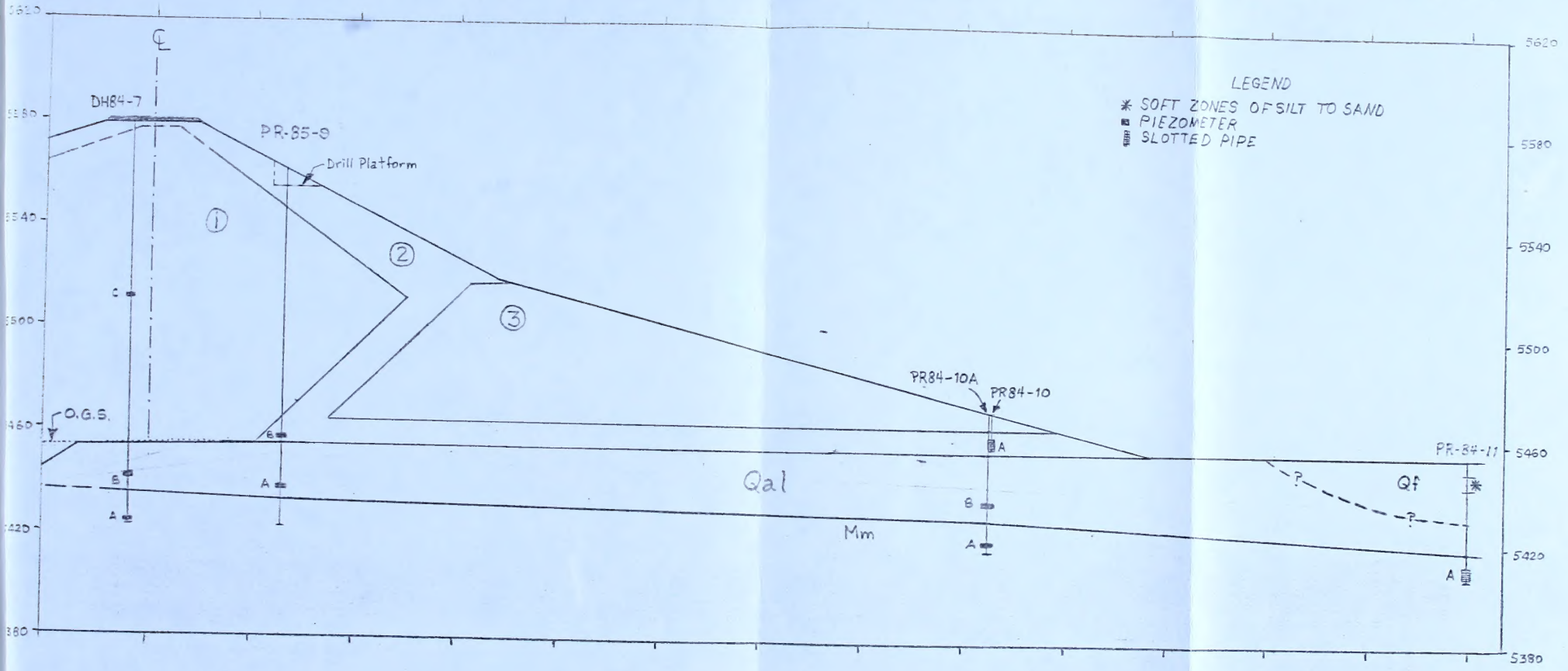
(2) Selected sand, gravel and cobb
crawler type tractor to 8 in

(3) Miscellaneous material compact
tractor to 12 inch layers.

N FEET

(4) Qal = Alluvial materials; Tb = B
Mm = Madison Limestone.

FIGURE 4



EXPLANATIONS

(1) Selected clay, silt, sand and gravel compacted by tamping rollers to 6 inch layers.
(2) Selected sand, gravel and cobbles compacted by crawler type tractor to 8 inch layers.
(3) Miscellaneous material compacted by crawler type tractor to 12 inch layers.
(4) Qal = Alluvial materials; Tb = Beaverhead Conglomerate; Mm = Madison Limestone.

NOTES

1. O.G.S. (ORIGINAL GROUND SURFACE) from drawing number 699-D-246.
2. Core trench excavation from drawing number 699-D-196.
3. Embankment zoning from drawing number 699-D-197.
4. Notes 2 and 3 modified by drilling.

CLARK CANYON DAM
SECTION 3-3
STATION 24+50

0 40 80
SCALE IN FEET